IDM UID
TVFDFR
VERSION CREATED ON / VERSION / STATUS
03 May 2017 / 1.1 / Approved
EXTERNAL REFERENCE / VERSION

Report

IVC PS busbar system drawing & analysis workload estimation

The purpose of this report is to preliminarily estimate IVC PS busbar system 2D drawing and analysis workload in the detailed design stage. The report is also intended for an initial assessment of installation workload.

Approval Process			
	Name	*Action*	*Affiliation*
Author	**Wang S.**	**03 May 2017:signed**	**IO/DG/COO/PED/EED/CPS**
Co-Authors			
Reviewers	**Shen H.**	**03 May 2017:recommended (Fast Track)**	**IO/DG/COO/PED/EED/CPS**
Previous Versions Reviews	**Tao J.** **Fortunato F.**	**28 Sep 2016:recommended v1.0** **03 Oct 2016:recommended v1.0**	**IO/DG/COO/PED/EED/CPS** **IO/DG/COO/PED/FEID**
Approver	**Benfatto I.**	**12 May 2017:approved**	**IO/DG/COO/PED/EED**
Document Security: Internal Use *RO: Shen Hong*			
Read Access	**LG: EED Head and Section Leaders and CPS, LG: Contractors, AD: ITER, AD: External Collaborators, AD: IO_Director-General, AD: EMAB, AD: OBS - Coil Power Supply Section (CPS), AD: Auditors, AD: ITER Management Assessor, project administrator, RO**		

Change Log			
IVC PS busbar system drawing & analysis workload estimation (TVFDFR)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	Approved	28 Sep 2016	
v1.1	Approved	03 May 2017	Modifications for the purpose of cost estimation: - P&ID for water collector panels are embedded for L3, the dimension and length of cooling pipes are indicated; - The workload estimation for water collector panels at L4 is added; - The summary of the workload estimation is revised accordingly;

Table of Contents

1 PURPOSE 2
2 SCOPE 2
3 DEFINITIONS 2
4 WORKLOAD ESTIMATION 2
4.1 SYSTEM OVERVIEW 2
4.2 SCOPE OF DRAWING & ANALYSIS/CHECK POINTS 3
4.3 METHODOLOGY 4
5 SUMMARY 6
6 REFERENCE 6
APPENDIX A: VS3 BUSBAR SYSTEM 7
APPENDIX B: ELM BUSBAR SYSTEM 11
APPENDIX C: IVC BUSBAR SUPPORT SYSTEM 17
APPENDIX D: IVC WATER COLLECTOR PANELS 25
APPENDIX E: IVC RIGID CONNECTION 31
APPENDIX F: IVC FLEXIBLE LINK 32

1 Purpose

The purpose of this report is to preliminarily estimate IVC PS busbar system 2D drawing and analysis workload in the detailed design stage.

The report is also intended for an initial assessment of installation workload.

2 Scope

The IVC PS busbar system is such designed to provide current for IVC during each working modes. The design is currently at a conceptual level and is subject to change as the design matures, however, the layout will remain largely the same from installation point of view. The system comprises of VS3 busbar, ELM busbar, support system, WCPs, rigid connection and flexible link.

3 Definitions

Include here all those relevant to this document.

IVC	In vessel coil
PS	Power supply
CC	Correction coil
TF	Toroidal field
WCPs	Water collector panels
EM	Electro-magnetic

For a complete list of ITER abbreviations see: ITER_D_2MU6W5 - ITER Abbreviations

4 Workload estimation

4.1 System overview

The IVC PS busbar system will distribute from takamak building L4 level to B1 level, the height is around 30 meters, and dimensions in horizontal direction are about 48 meters and 62 meters. The side view and bird view are shown in Figure 4-1 and Figure 4-2, respectively.

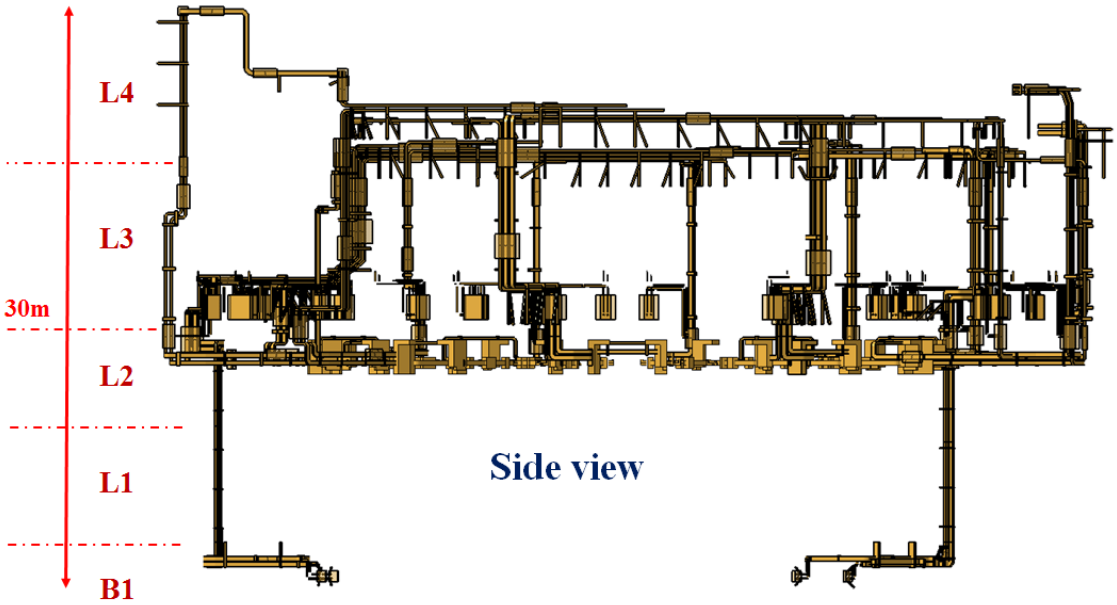


Figure 4-1 Side view of IVC PS busbar system

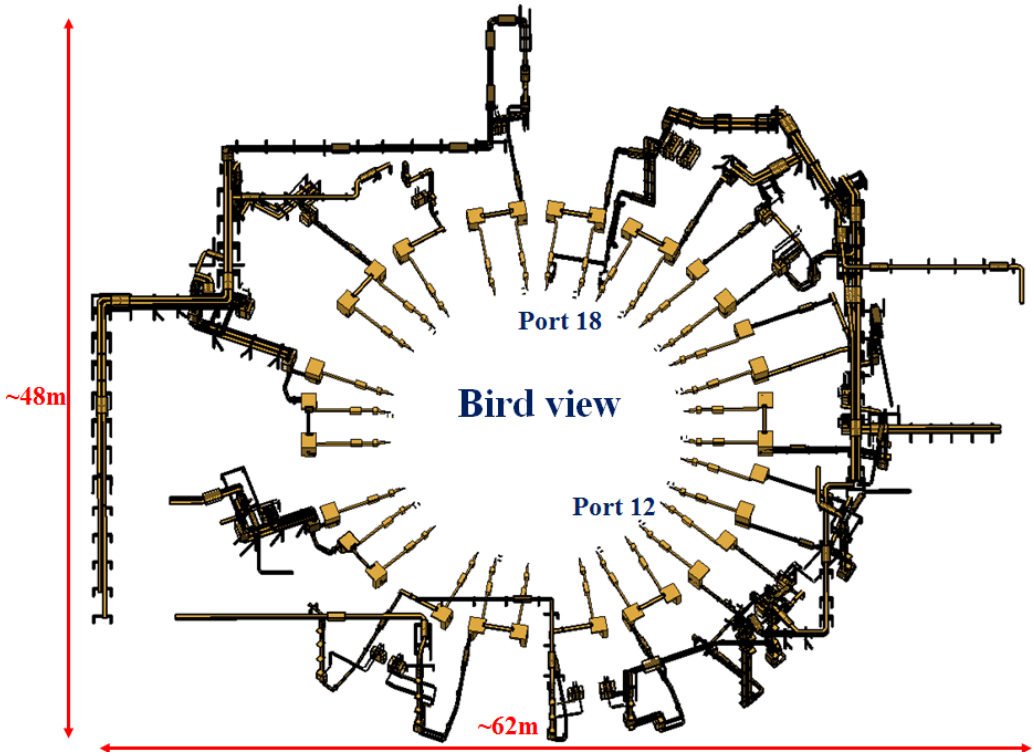


Figure 4-2 Bird view of IVC PS busbar system

There are 35 circuits in total, 8 for VS busbar which end at L2 and B1 level and 27 for ELM busbar which end at L2 level only. The typical design of busbar is taken from [1] for reference, its normal profile of busbar configuration is shown in Figure 4-3.

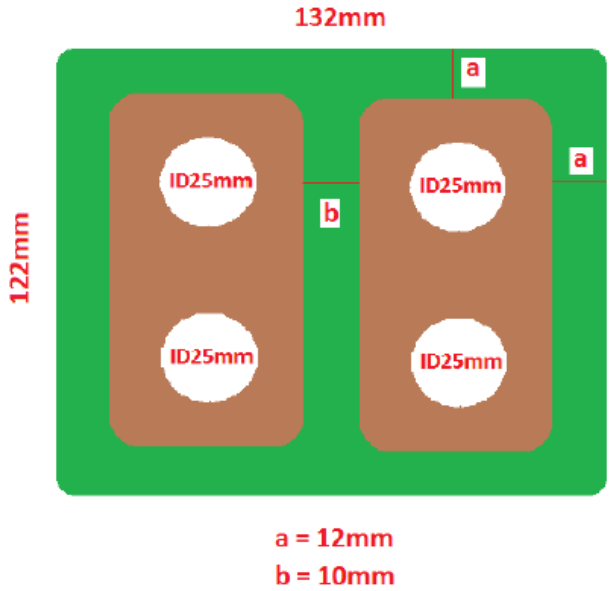


Figure 4-3 Normal Profile of Busbar Configuration (Typical design)

4.2 Scope of drawing & analysis/check points

To give the quantitative estimation on the workload, the IVC PS busbar system is broken down into small groups based on their functions. To obtain a more clear idea after breakdown, 2D drawings and analysis/check points are defined below to count the specific workload in the detailed design. The analysis/check point just represents the area/aspect where we need to

focus on, does not necessarily require an individual report. They could be (or not) grouped in the same reports with several analysis/check points.

- **2D Drawing:**

- **A0 format drawing**: A0 drawing is adopted for the large-scale busbar circuit assembly.

- **A1 format drawing**: A1 drawing is adopted for the busbar sections, WCPs, rigid connection and complicated support.

- **A2 & A3 drawing**: A1 format drawing could be split into two A2 drawings or four A3 drawings for each sheet, e.g. simple support, flexible link and cooling pipes.

- **Analysis/Check point:**

- **Electrical analysis (r1):** electrical characteristics, classified by circuit;

- **Electrical magnetic analysis (r2)**: magnetic field and EM load, classified by circuit;

- **Electrical thermal analysis (r3)**: global and local thermal performance with current and cooling, especially for flexible link and rigid connection, classified by circuit and area;

- **Busbar stress analysis (r4)**: design justification with loads (gravity, seismic, thermal, EM, and SL-3 in case of hard core components), classified by circuit and area;

- **Support analysis (r5)**: support design justification and embedded plate verification, classified by circuit and area;

4.3 Methodology

With the definitions given above, the breakdown of IVC PS busbar system is executed group by group. The breakdowns of busbar system geometry are made, the numbers of components are counted, and the 2D drawing & analysis/check point are estimated approximately. The detailed information of breakdown for each group is given in the appendixes as follow.

Appendix A: VS3 busbar system

Appendix B: ELM busbar system

Appendix C: IVC busbar support system

Appendix D: IVC water collector panels

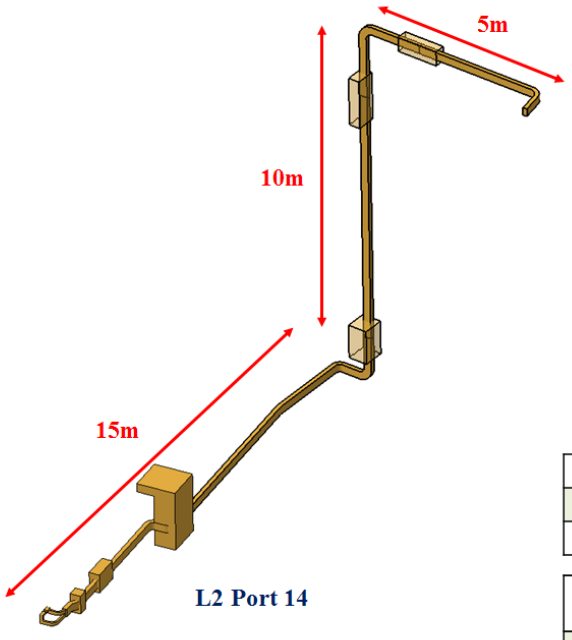
Appendix E: IVC rigid connection

Appendix F: IVC flexible link

To explain the methodology used in the breakdown of IVC PS busbar system clearly, one example is given below. As shown in Figure 4-4, one circuit of VS3 PS busbar located at L2 port cell 14 is demonstrated with rough dimensions. Following procedures are respected to estimate the 2D drawing and analysis/check point:

1) The numbers of rigid connection (space reservation wih transparent box) and flexible link (space reservation with L shape solid box) are counted, respectively.
2) The number of busbar sections divided rigid connection and flexible link are counted. (The typical length of busbar sections is about seven or eight meters.)
3) The reference outline drawings on CC and TF busbar from RFDA give a general idea how complicated the drawing will be, based on which the number and size of busbar section 2D drawings are estimated.
4) The analysis/check points on each type of analysis are estimated, special attentions have been paid on flexible part and the interface area (with VS3 coil feeder).
5) The workload estimation on the rigid connection and flexible link will be given hereafter in the appendix thanks to our efforts on component design standardization.

VS3 PS busbar system breakdown



Item	Config	No.
Rigid connection	1 busbar	3
Flexible link	1 layer	2

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	5	1/5	1/1/2/2

Figure 4-4 Breakdown example of one VS3 busbar circuit

In addition to the methodology abovementioned, some other principles are followed:

- All the designs are currently in conceptual design stage, which are subject to change in the future.
- The reference drawings for each kind of component are outline drawings, while more detailed drawings are foreseen in detailed design stage.

- Our best efforts have been made to standardize the component design, especially on support design, which will decrease the number of 2D drawings and analysis/check points apparently.
- Efforts have been made to group the similar items and analysis/check points, some variations are expected. Therefore, a proper amplification factor is adopted to avoid underestimating the workload, especially on support design.

5 Summary

Following the methodology given above, the breakdown of IVC PS busbar system is executed. The number of 2D drawings and analysis/check points are summarized in following table for each item. Finally, more than one thousand components are foreseen, about 768 A1 format drawing (equivalent) and about 447 analysis/check points are required in the detailed design stage.

– **Number of drawing and analysis/check point**

Item	No.	Drawing A0/A1/A2/A3	Analysis/check point r1/r2/r3/r4/r5
VS3 busbar	60	8/60/0/0	8/8/16/20/0
ELM busbar	209	27/209/0/0	27/27/54/67/0
Support	417	0/152/28/0	0/0/0/0/102
WCPs	72	0/160/0/0	---
Cooling pipe	306	0/0/0/238	0/0/0/72/0
Rigid connection	112	0/40/0/0	0/0/20/20/0
Flexible link	70	0/3/0/0	0/0/3/3/0

	Drawing A0/A1/A2/A3	Analysis/check point r1/r2/r3/r4/r5
Total	35/624/28/238	35/35/93/182/102

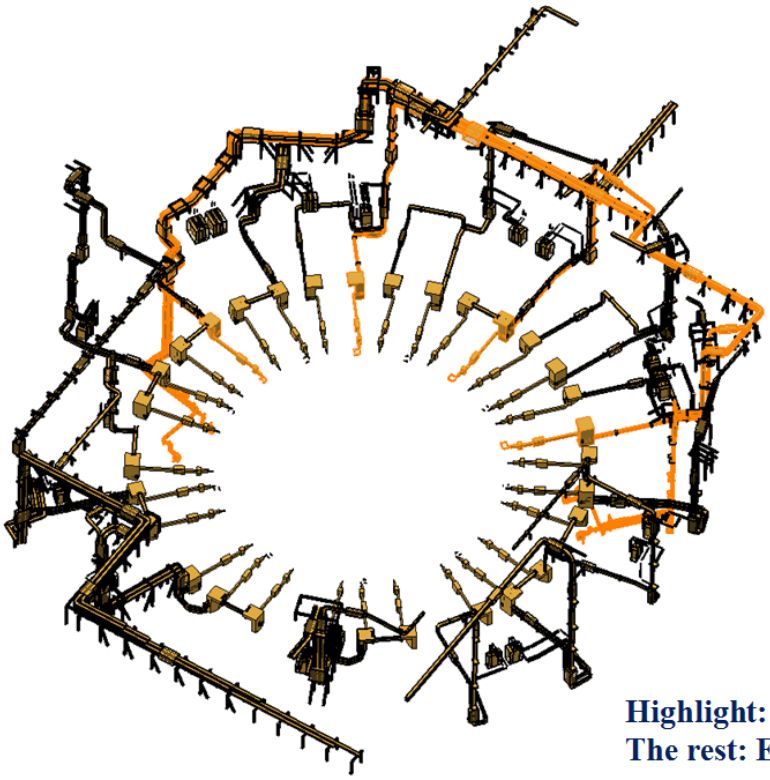
Total (equivalent) 768 A1 447

6 Reference

[1] IVC PS Busbar - SDD and Functional Analysis, ITER_D_QPTP96 v9.5

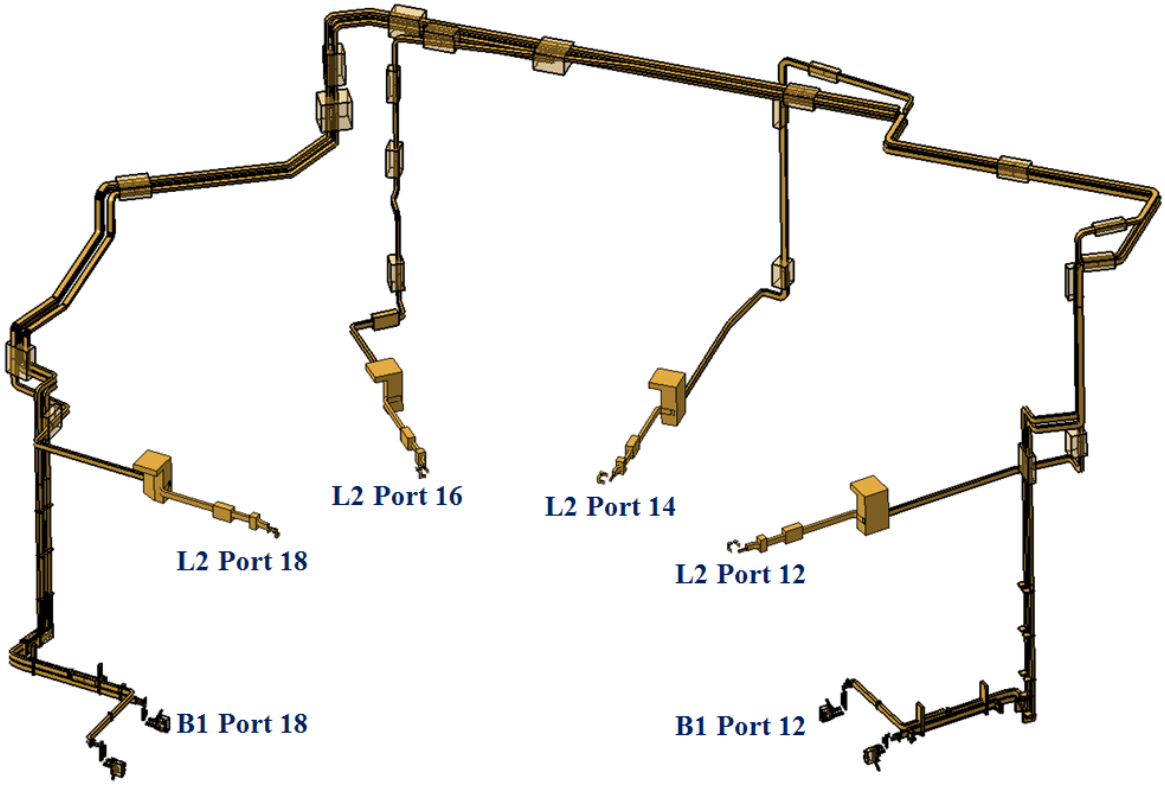
Appendix A: VS3 busbar system

IVC PS busbar system

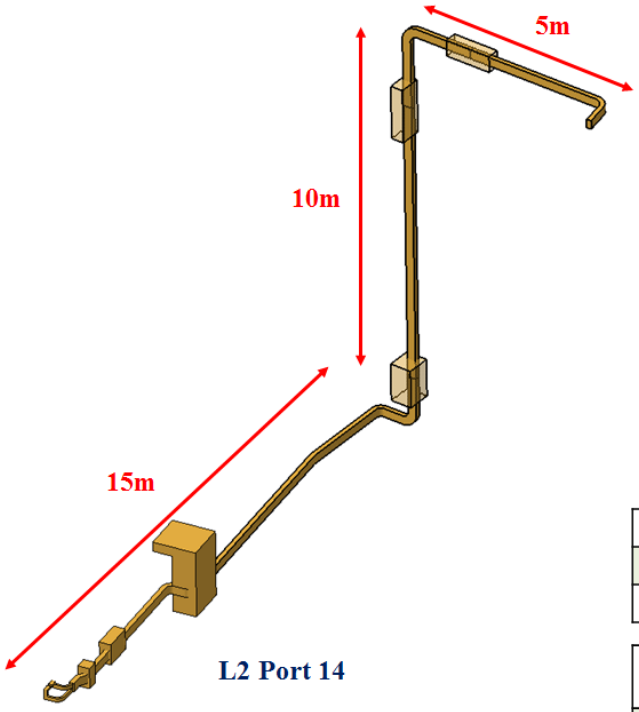


Highlight: VS3 busbar system
The rest: ELM busbar system

VS3 PS busbar system



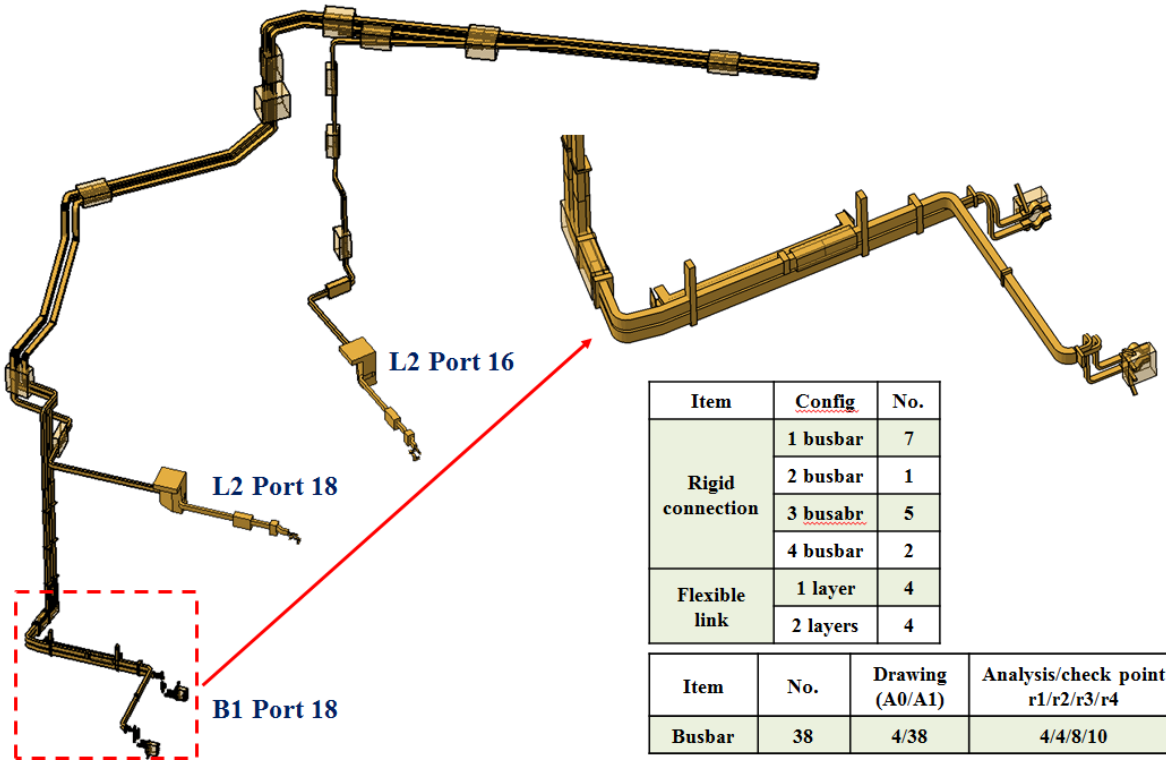
VS3 PS busbar system breakdown



Item	Config	No.
Rigid connection	1 busbar	3
Flexible link	1 layer	2

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	5	1/5	1/1/2/2

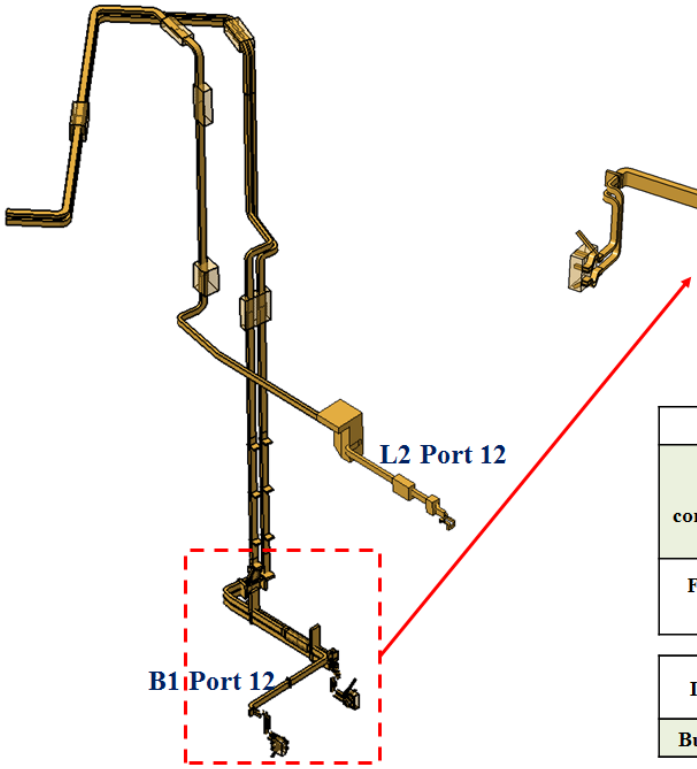
VS3 PS busbar system breakdown



Item	Config	No.
Rigid connection	1 busbar	7
	2 busbar	1
	3 busabr	5
	4 busbar	2
Flexible link	1 layer	4
	2 layers	4

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	38	4/38	4/4/8/10

VS3 PS busbar system breakdown

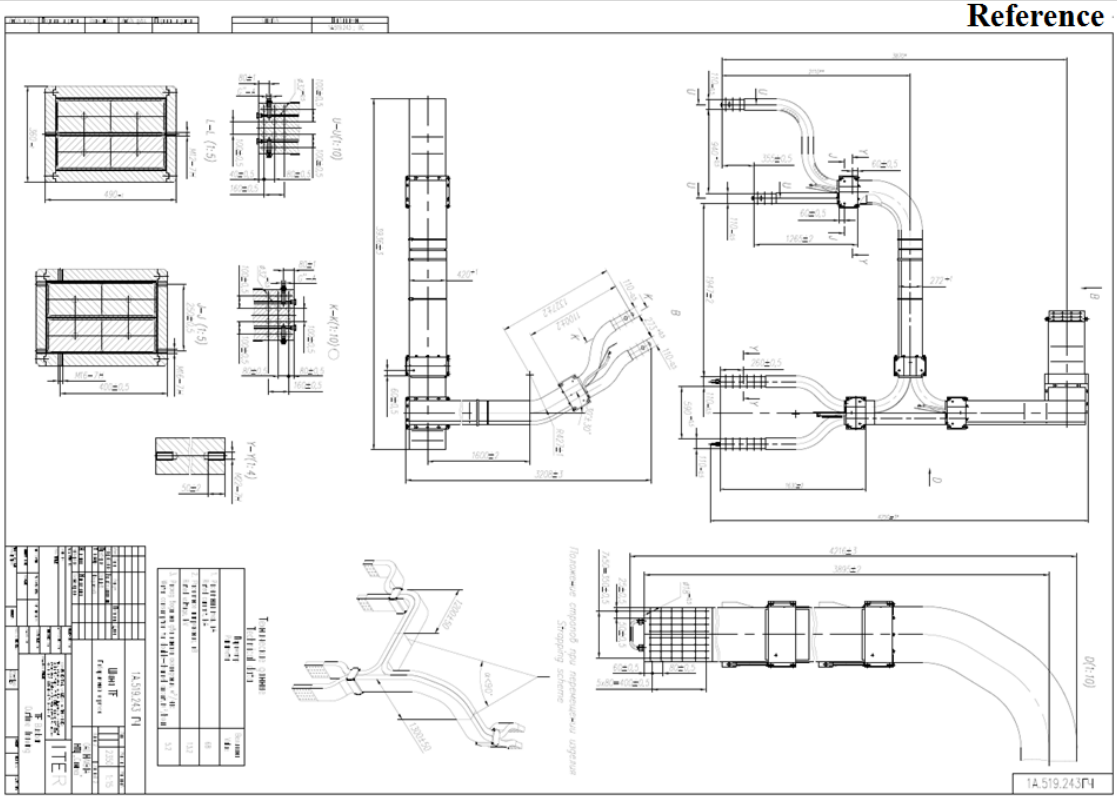


Item	Config	No.
Rigid connection	1 busbar	6
	2 busbar	2
	3 busabr	1
Flexible link	1 layer	2
	2 layers	4

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	17	3/17	3/3/6/8

Reference: TF Busbar outline drawing

Reference



VS3 PS busbar system

❑ SUMMARY

– Number of rigid connection and flexible link

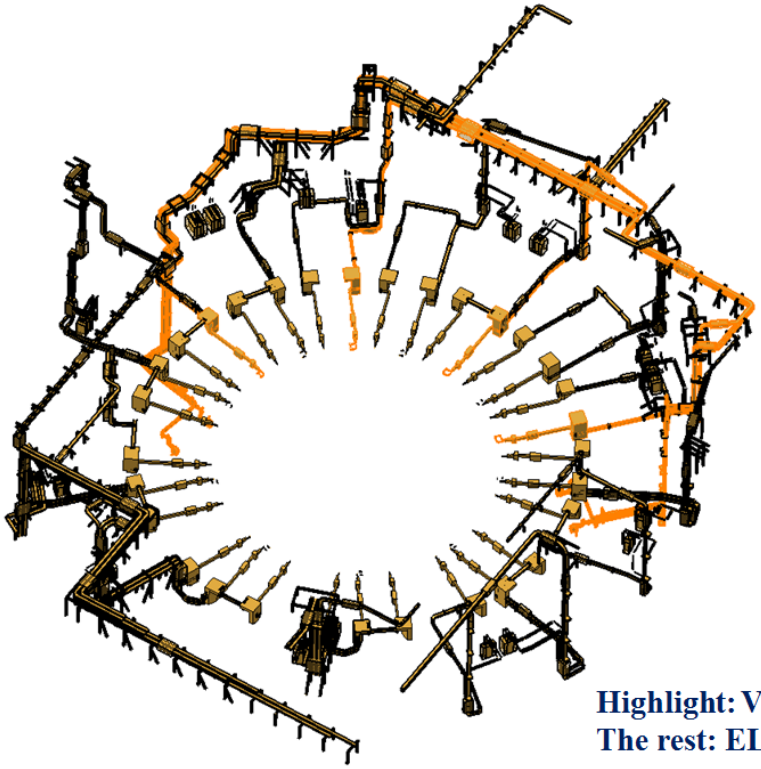
Item	Config	No.
Rigid connection	1 busbar	16
	2 busbar	3
	3 busabr	6
	4 busbar	2
Flexible link	1 layer	8
	2 layers	8

– Number of drawing and analysis/check point

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	60	8/60	8/8/16/20

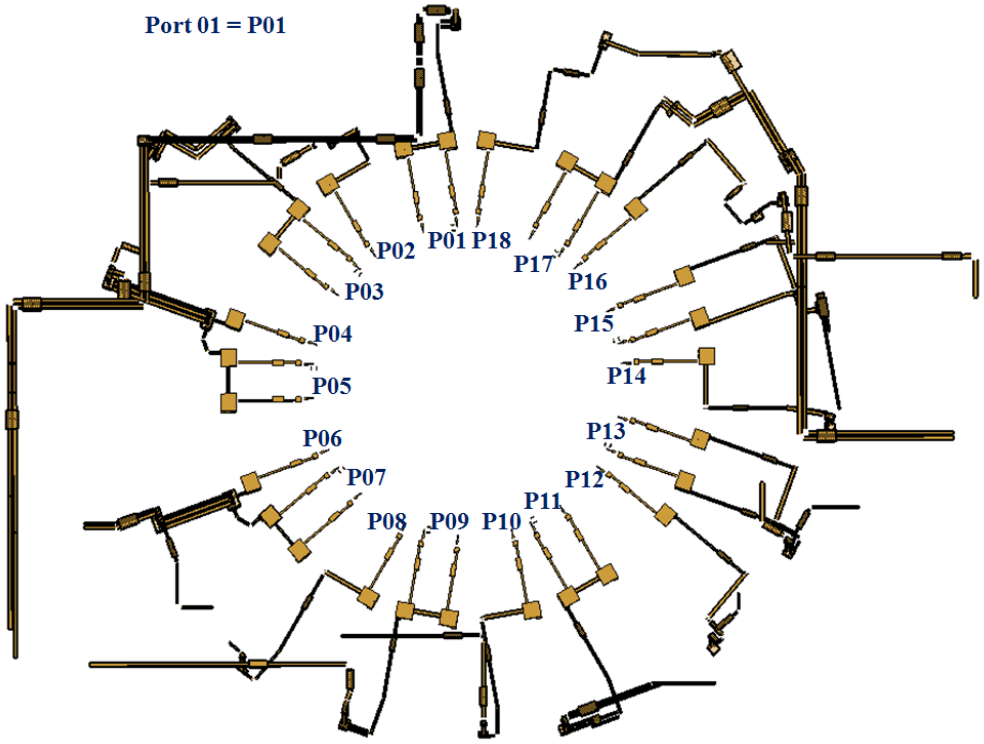
Appendix B: ELM busbar system

IVC PS busbar system



Highlight: VS3 busbar system
The rest: ELM busbar system

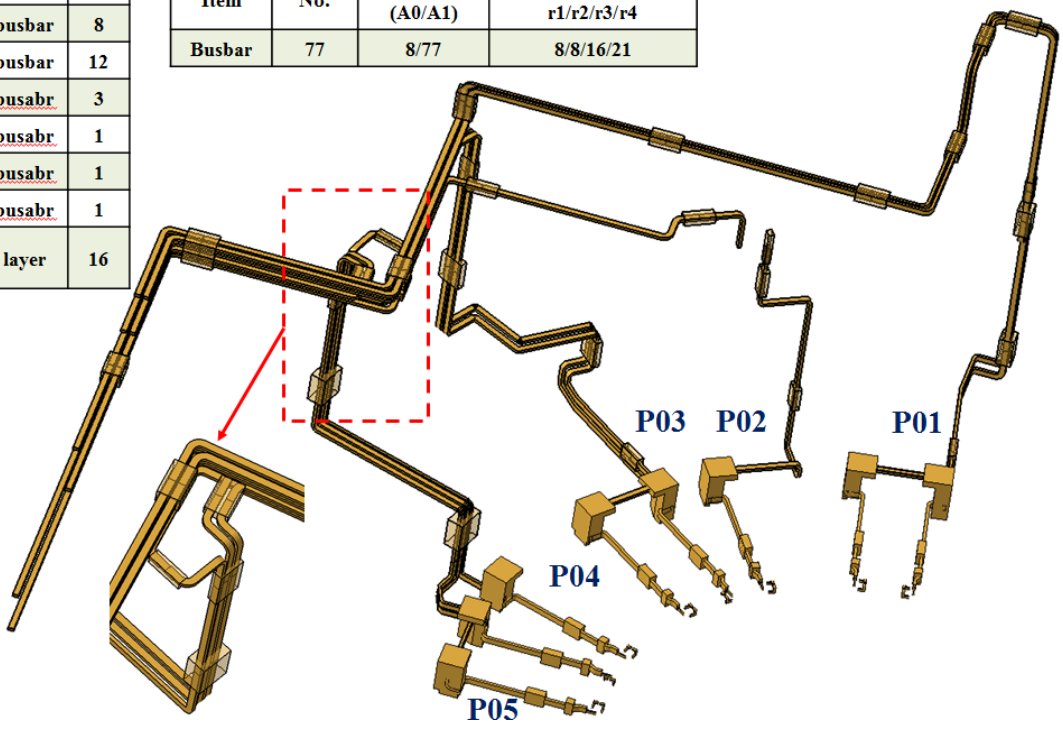
ELM PS busbar system



ELM PS busbar system breakdown

Item	Config	No.
Rigid connection	1 busbar	8
	2 busbar	12
	3 busabr	3
	4 busabr	1
	5 busabr	1
	8 busabr	1
Flexible link	1 layer	16

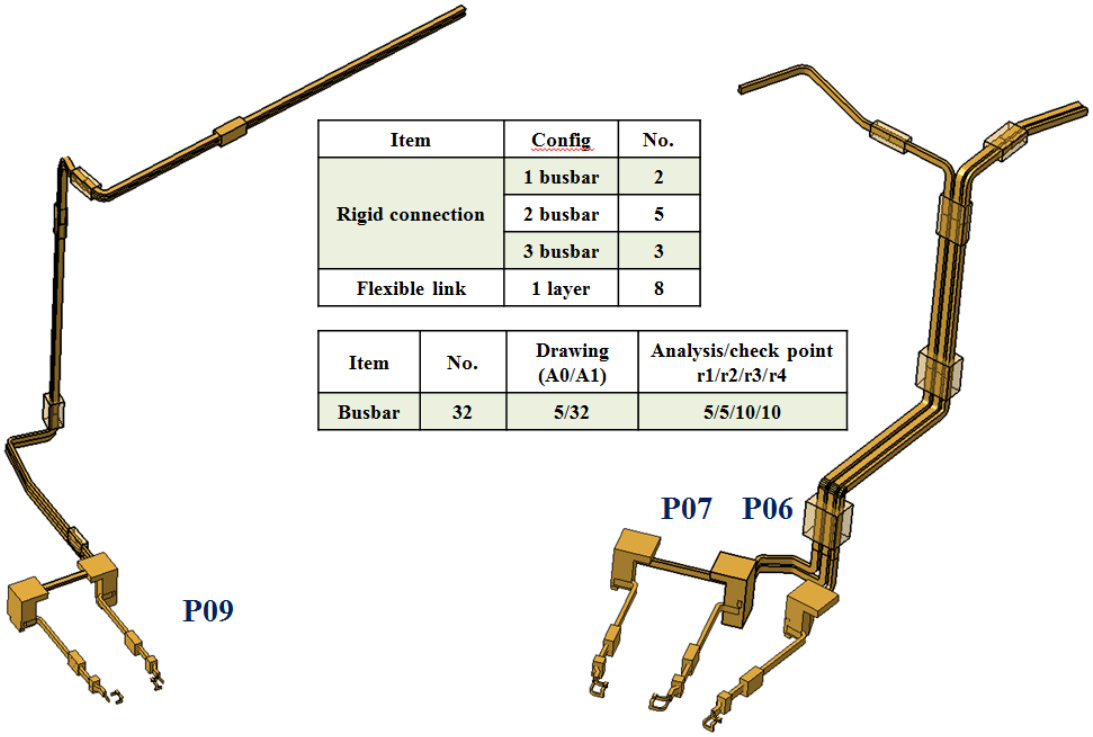
Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	77	8/77	8/8/16/21



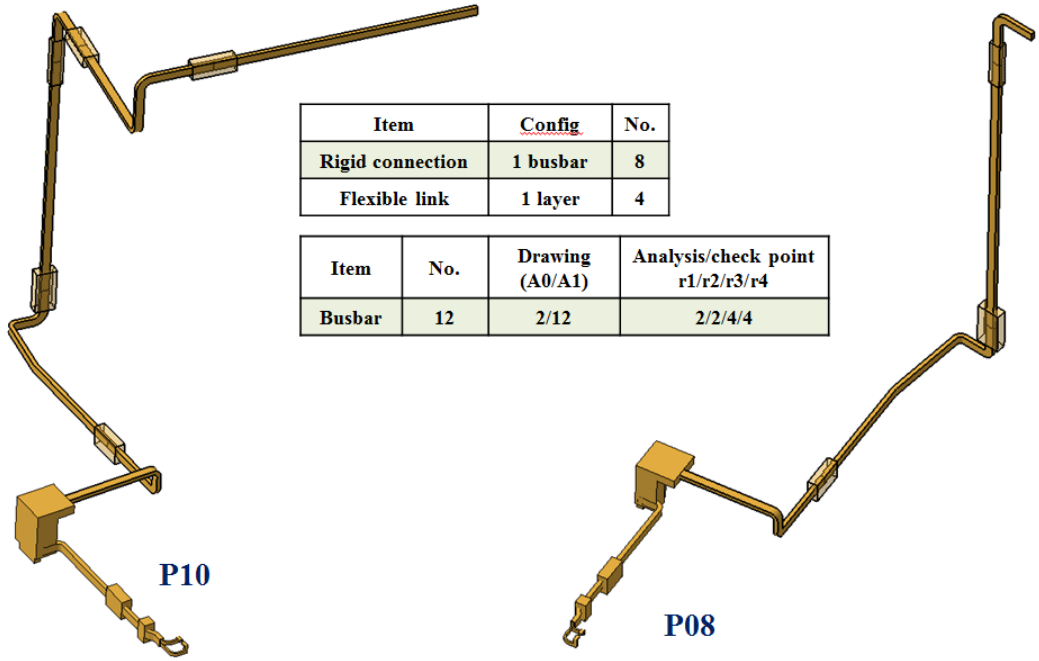
ELM PS busbar system breakdown

Item	Config	No.
Rigid connection	1 busbar	2
	2 busbar	5
	3 busbar	3
Flexible link	1 layer	8

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	32	5/32	5/5/10/10



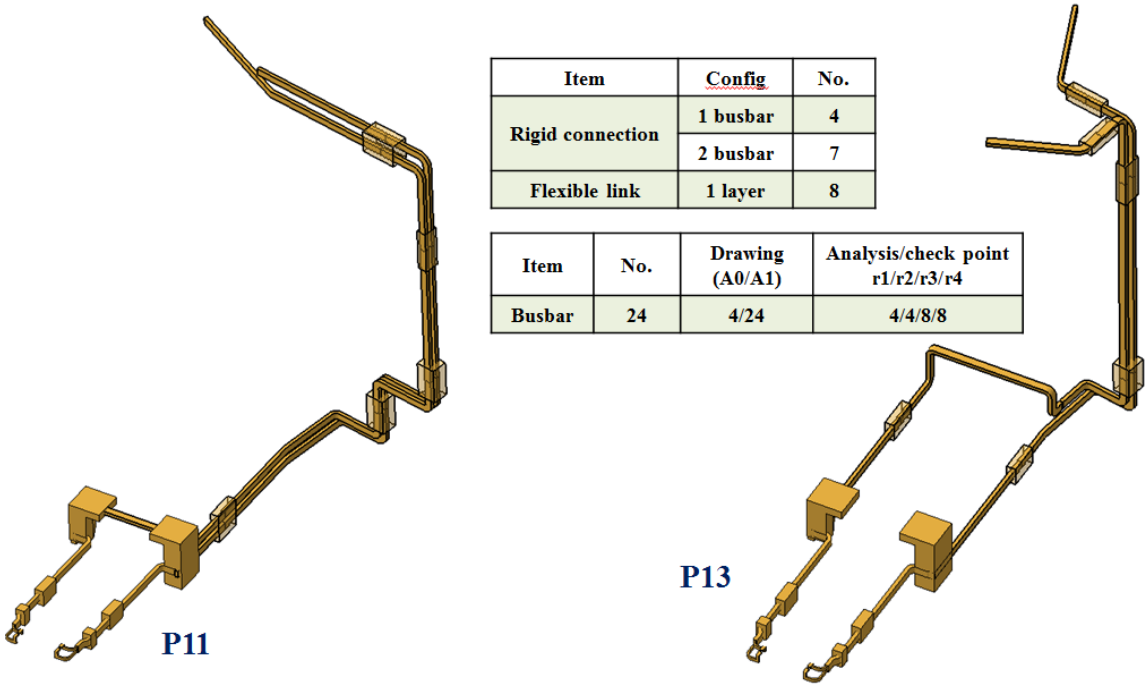
ELM PS busbar system breakdown



Item	Config	No.
Rigid connection	1 busbar	8
Flexible link	1 layer	4

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	12	2/12	2/2/4/4

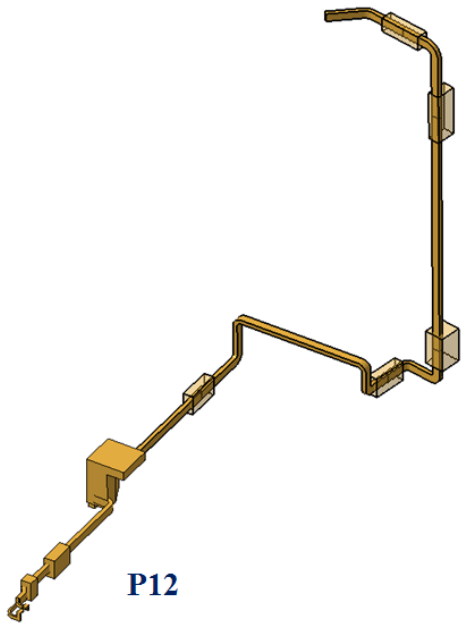
ELM PS busbar system breakdown



Item	Config	No.
Rigid connection	1 busbar	4
	2 busbar	7
Flexible link	1 layer	8

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	24	4/24	4/4/8/8

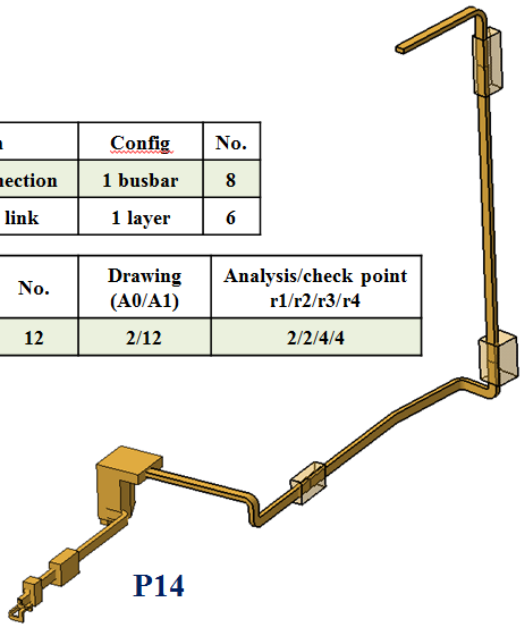
ELM PS busbar system breakdown



P12

Item	Config	No.
Rigid connection	1 busbar	8
Flexible link	1 layer	6

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	12	2/12	2/2/4/4

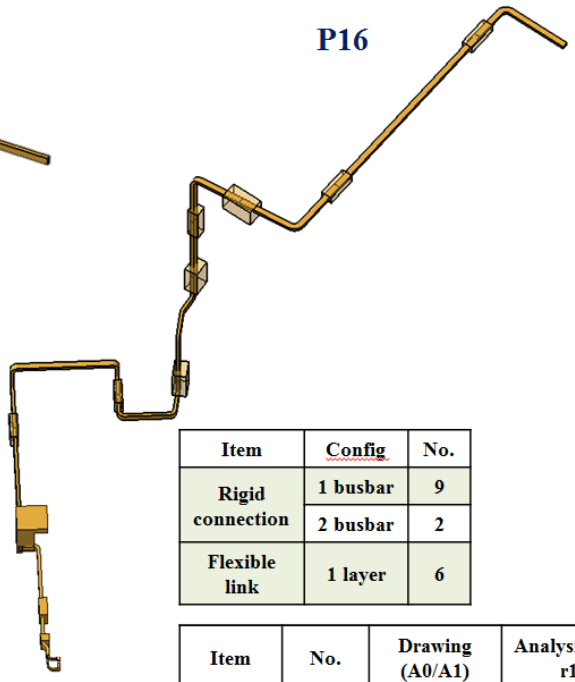


P14

ELM PS busbar system breakdown

P15

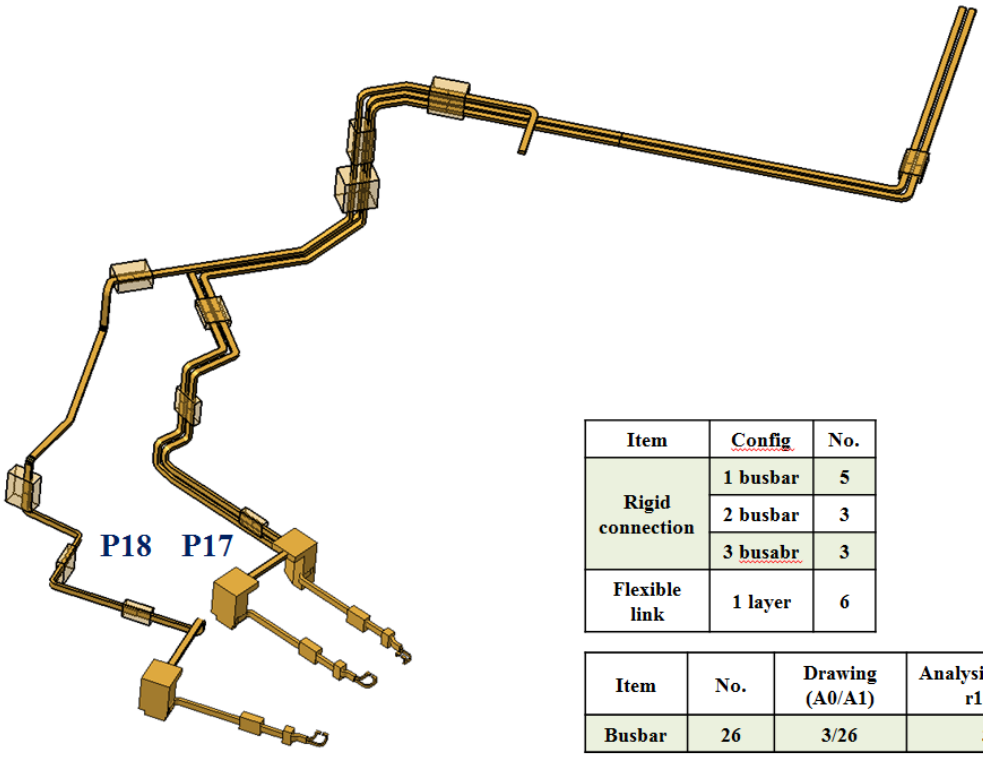
P16



Item	Config	No.
Rigid connection	1 busbar	9
	2 busbar	2
Flexible link	1 layer	6

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	26	3/26	3/3/6/8

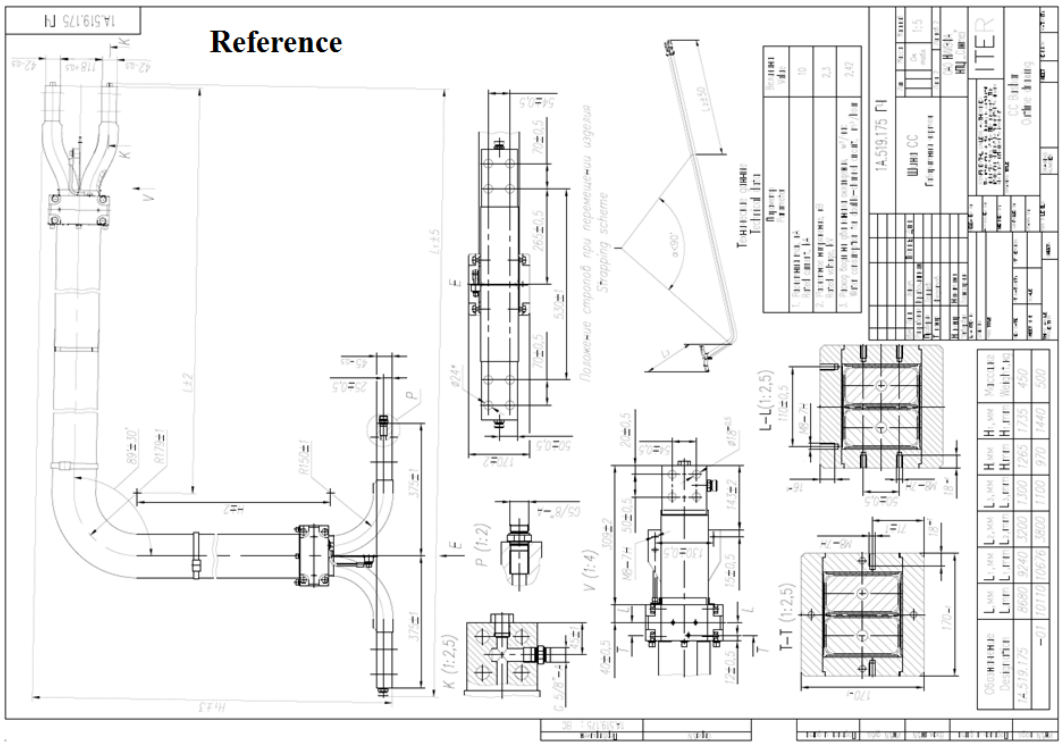
ELM PS busbar system breakdown



Item	Config	No.
Rigid connection	1 busbar	5
	2 busbar	3
	3 busabr	3
Flexible link	1 layer	6

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	26	3/26	3/3/6/8

Reference: CC Busbar outline drawing



ELM PS busbar system

❑ SUMMARY

– Number of rigid connection and flexible link

Item	Config	No.
Rigid connection	1 busbar	44
	2 busbar	29
	3 busabr	9
	4 busbar	1
	5 busbar	1
	8 busbar	1
Flexible link	1 layer	54

– Number of drawing and analysis/check point

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	209	27/209	27/27/54/67

ELM & VS3 PS busbar system

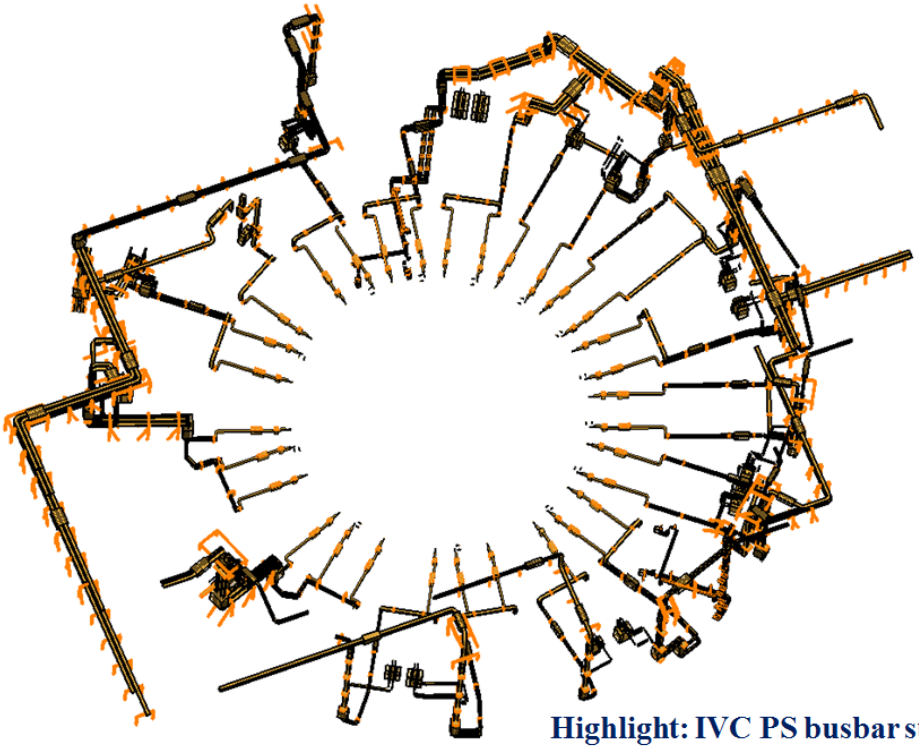
❑ SUMMARY for all busbar

– Number of drawing and analysis/check point

Item	No.	Drawing (A0/A1)	Analysis/check point r1/r2/r3/r4
Busbar	269	35/269	35/35/70/87

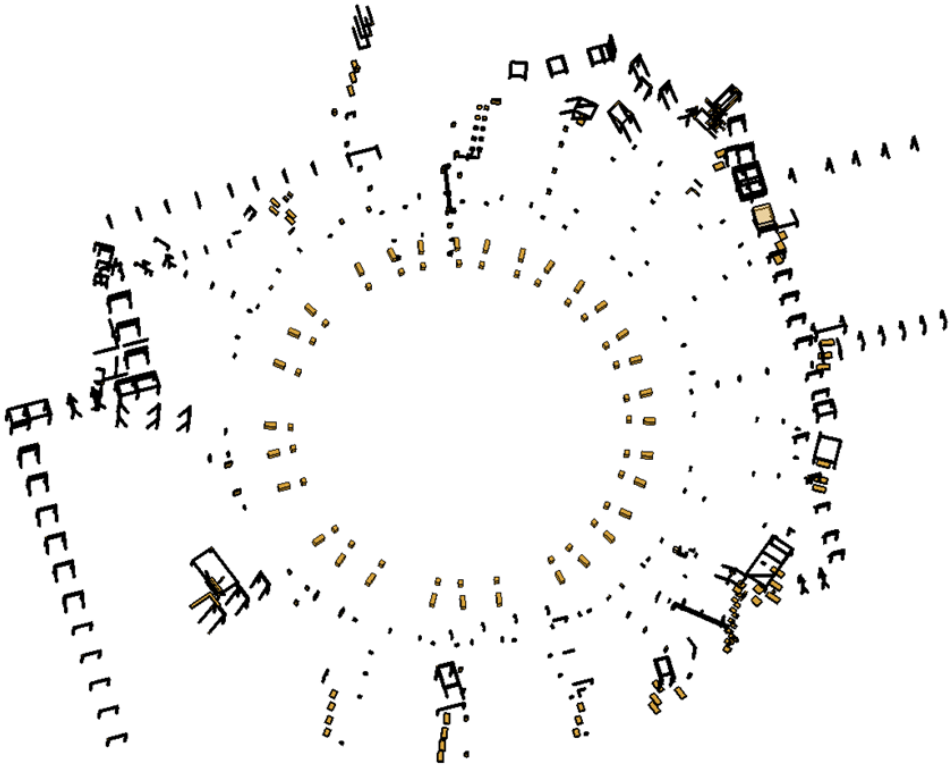
Appendix C: IVC busbar support system

IVC PS busbar support system

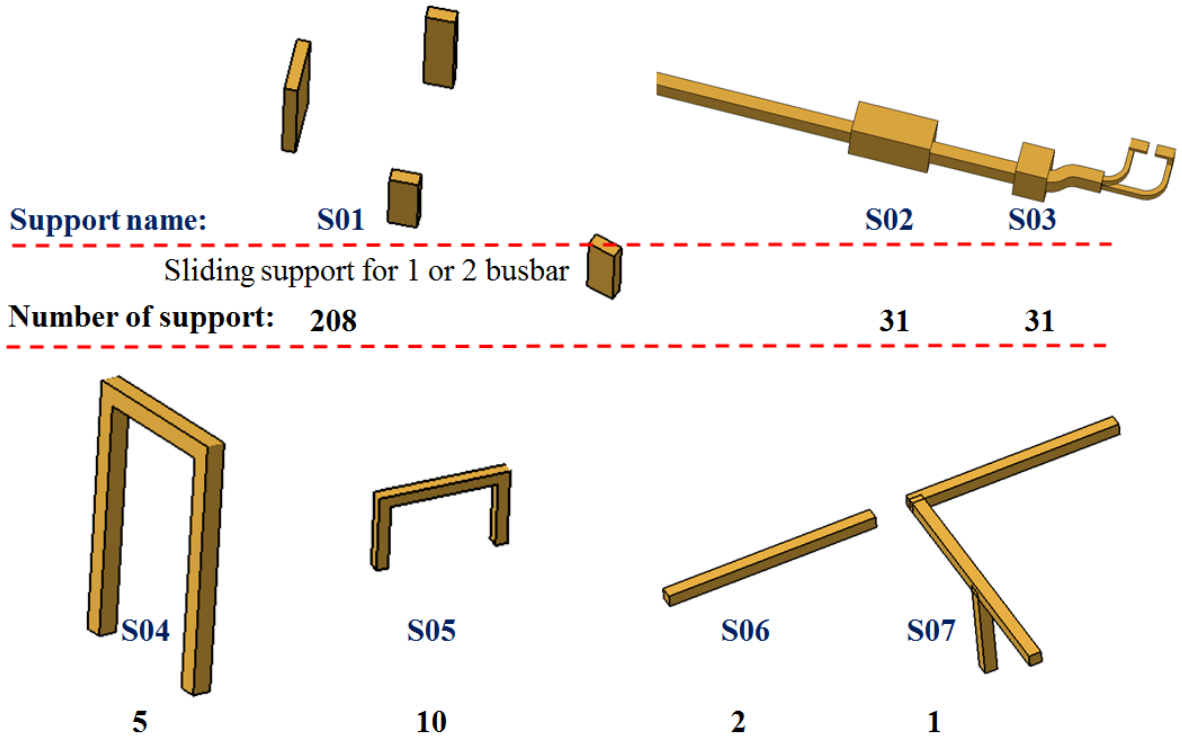


Highlight: IVC PS busbar support system

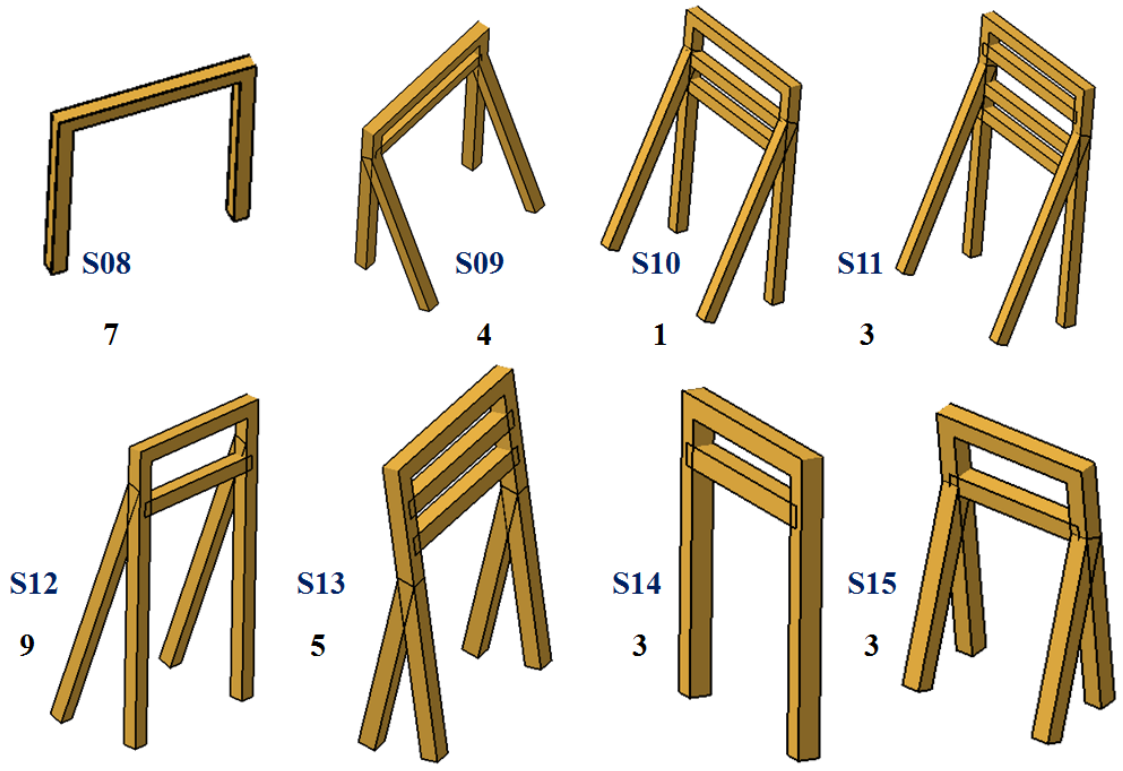
IVC PS busbar support system



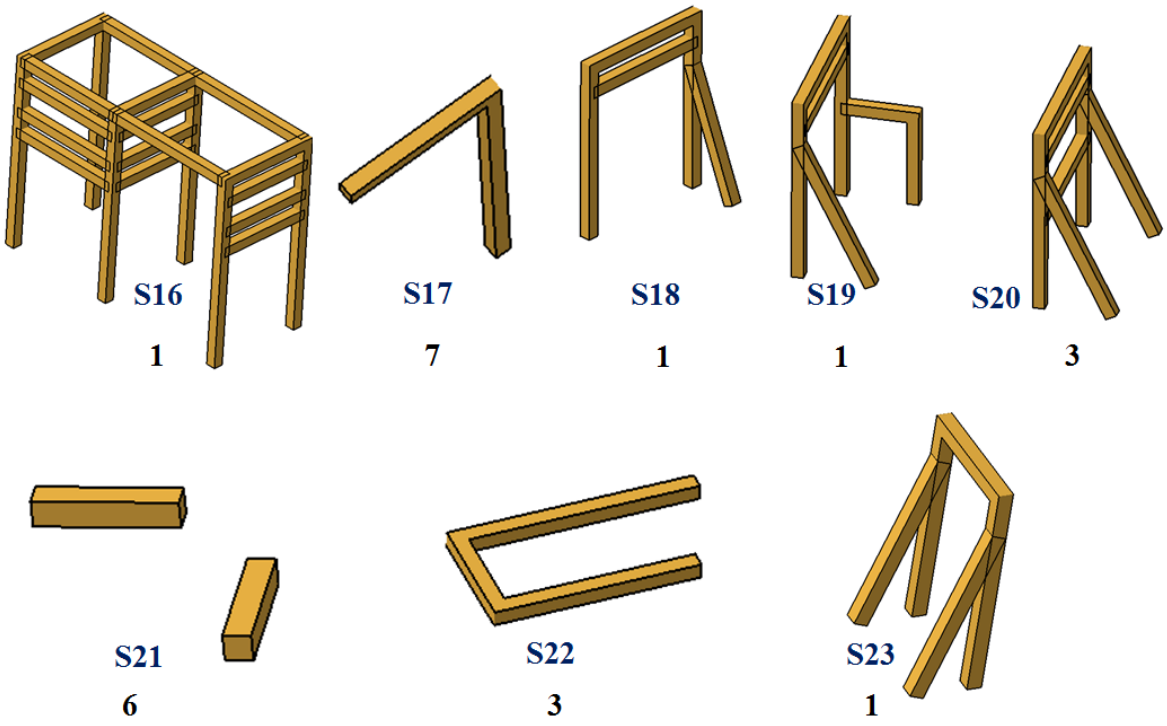
IVC PS busbar support system breakdown



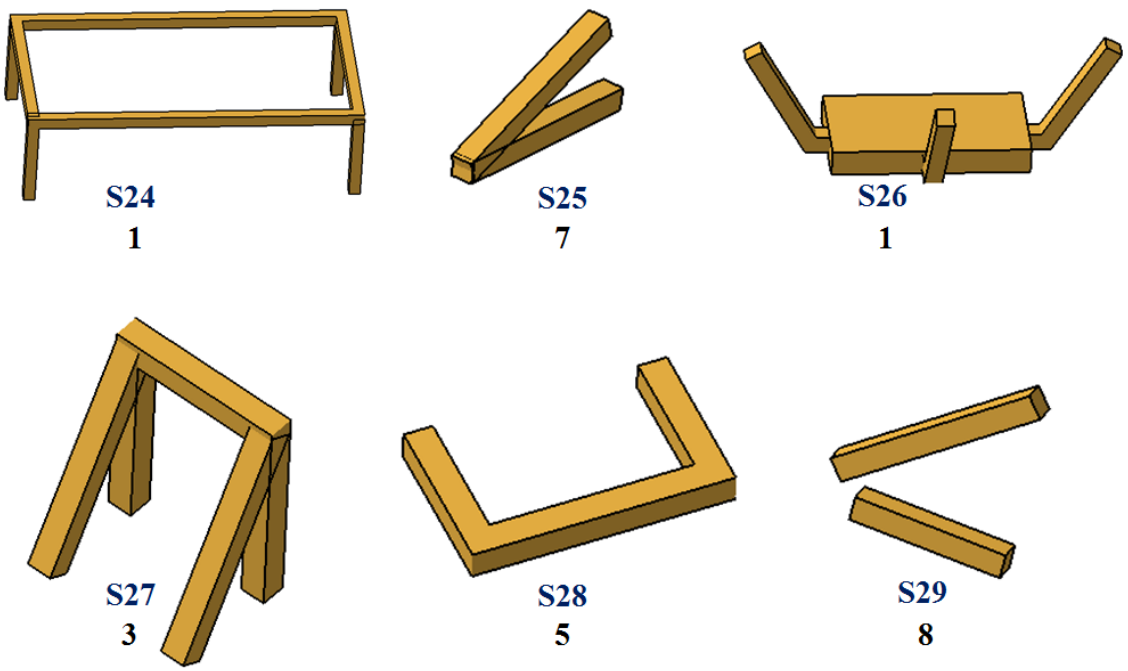
IVC PS busbar support system breakdown



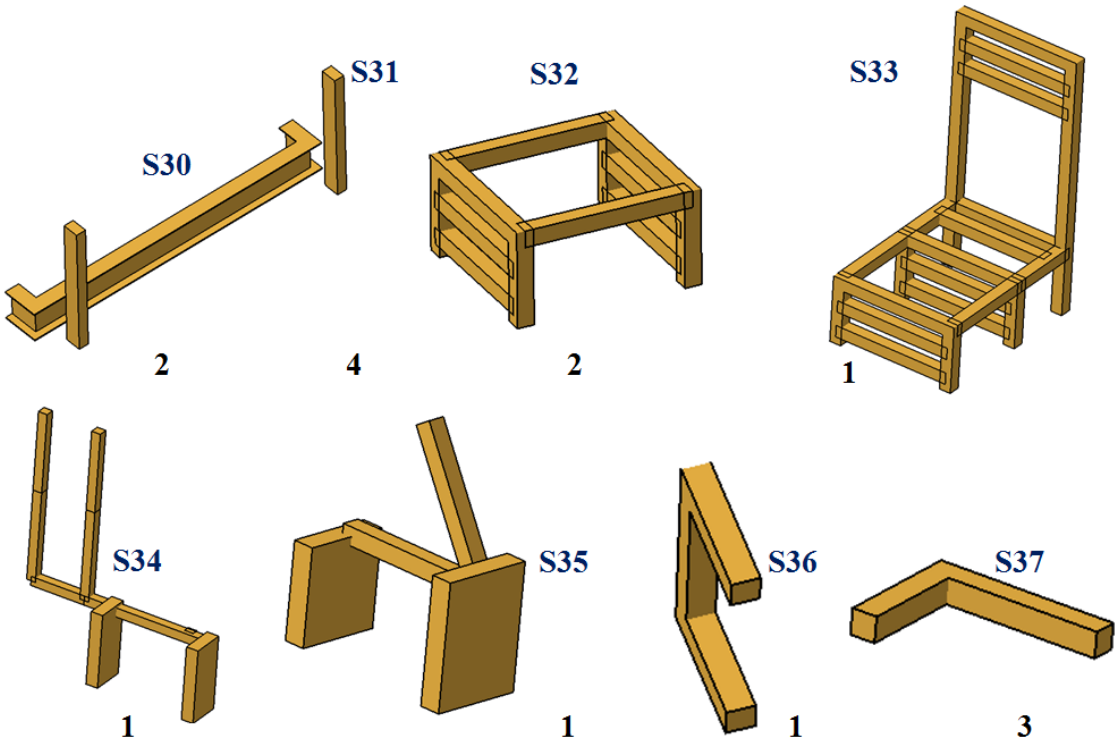
IVC PS busbar support system breakdown



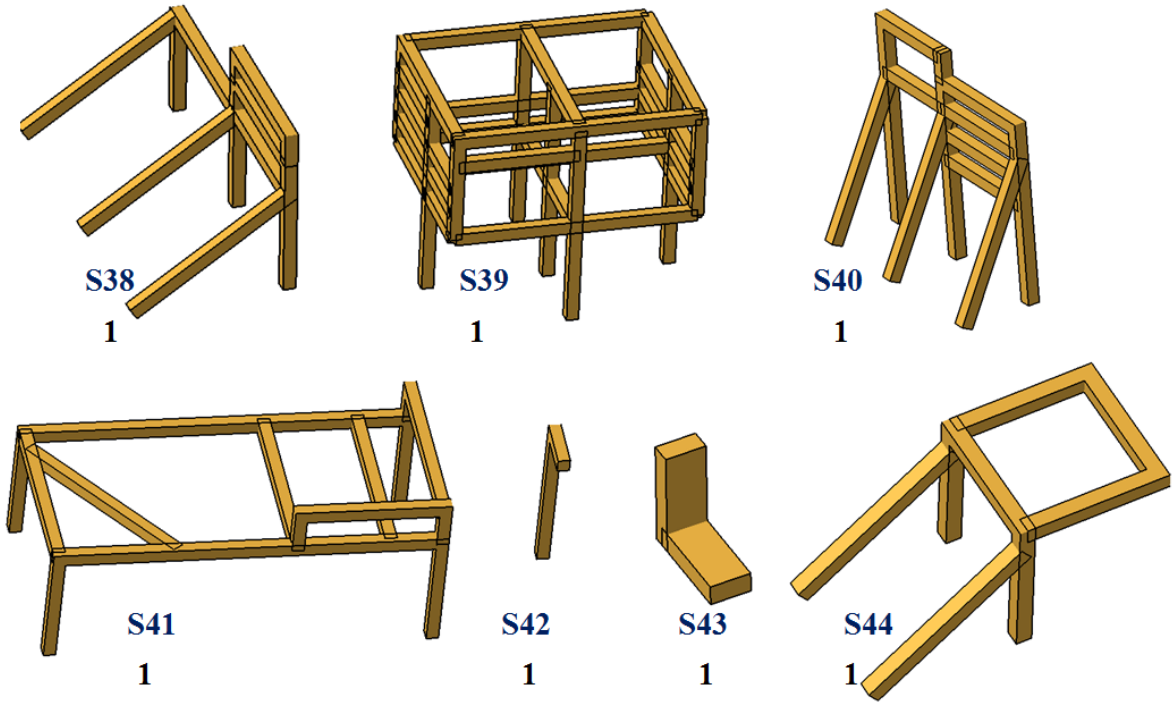
IVC PS busbar support system breakdown



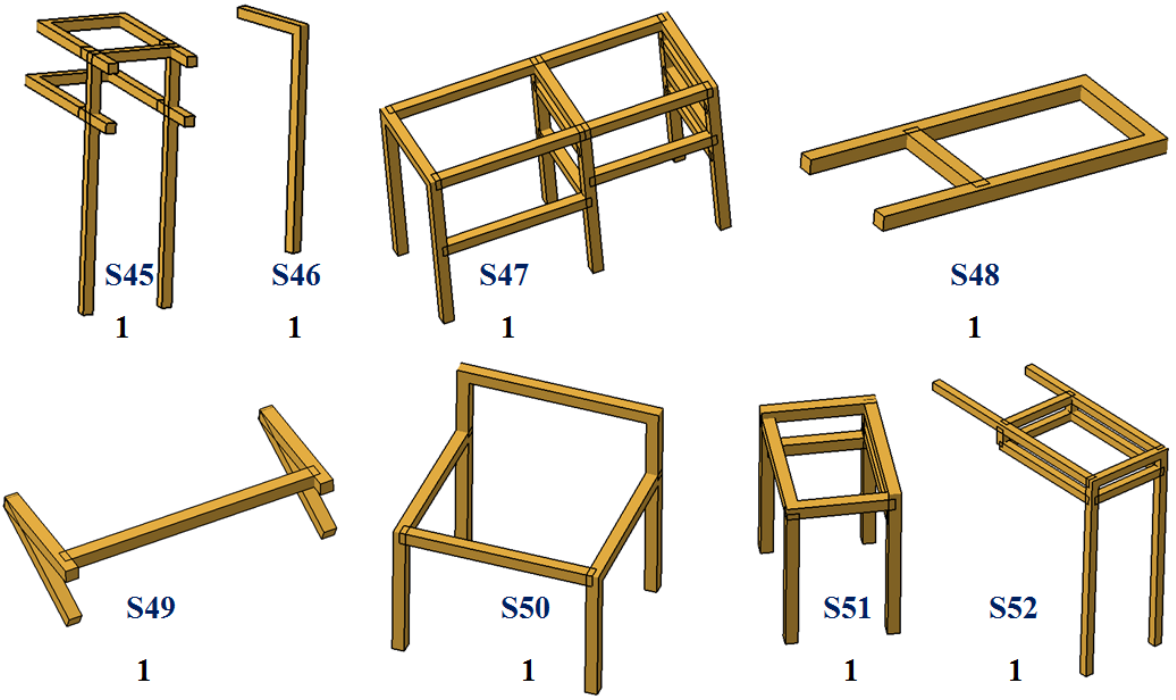
IVC PS busbar support system breakdown



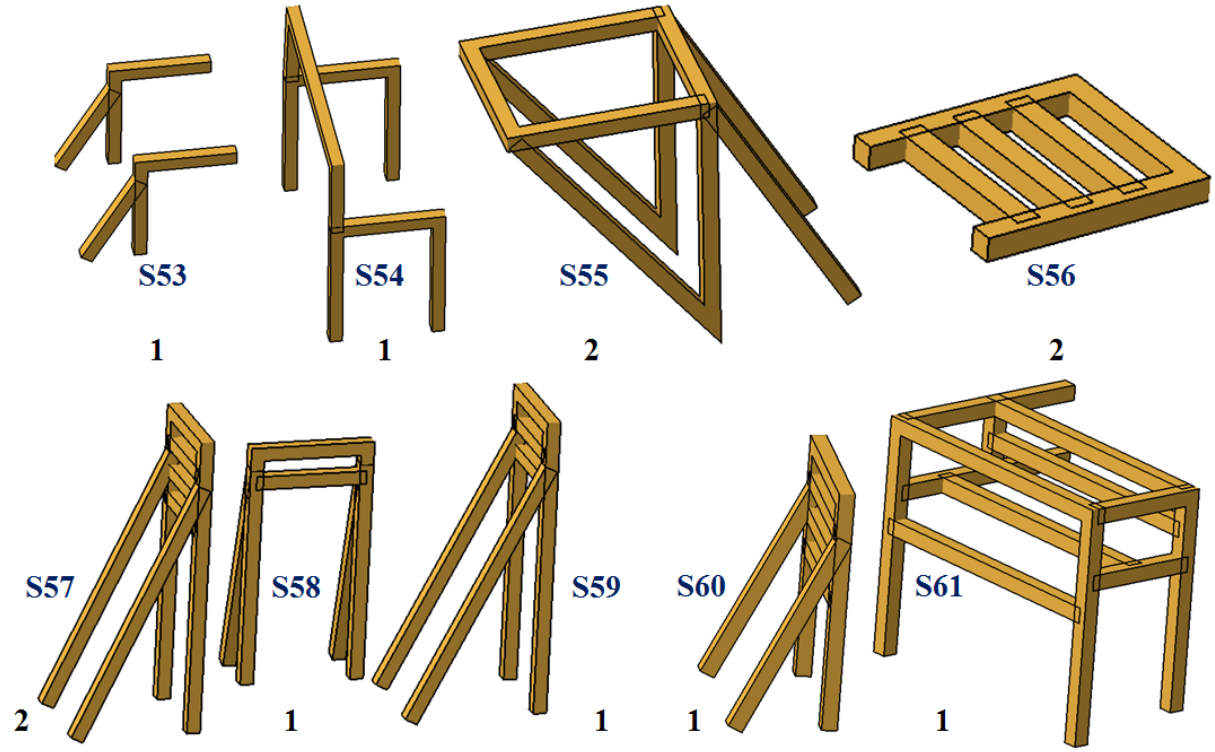
IVC PS busbar support system breakdown



IVC PS busbar support system breakdown

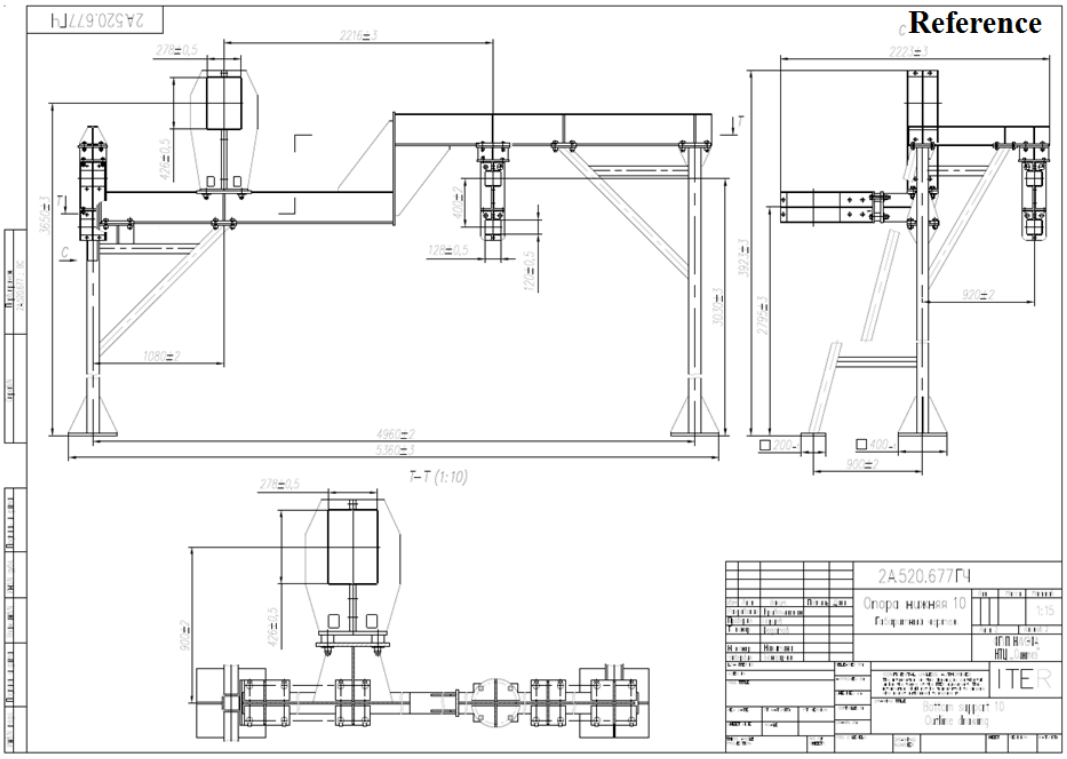


IVC PS busbar support system breakdown



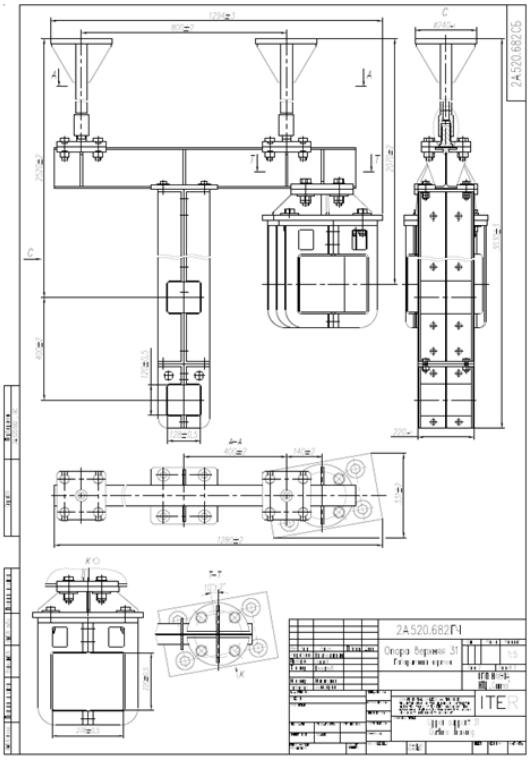
Reference: Bottom support outline drawing

Reference



Reference: Upper support outline drawing

Reference



IVC PS busbar support system

Type	No.	Design variations	Drawing (A1/A2)	Analysis point r5	Note
S01	208	4	0/4	16	
S02	31	2	0/2	2	
S03	31	2	0/2	2	
S04	5	2	0/2	2	
S05	10	2	0/2	2	
S06	2	2	0/2	2	
S07	1	1	1/0	1	
S08	7	2	2/0	2	
S09	4	2	2/0	2	
S10	1	1	2/0	1	
S11	3	2	2/0	2	
S12	9	2	2/0	2	
S13	5	2	2/0	2	
S14	3	2	2/0	2	
S15	3	1	1/0	1	
S16	1	1	1/0	1	
S17	7	2	2/0	2	
S18	1	1	1/0	1	

Type	No.	Design variations	Drawing (A1/A2)	Analysis point r5	Note
S19	1	1	1/0	1	
S20	3	2	2/0	2	
S21	6	2	2/0	2	
S22	3	2	2/0	2	
S23	1	1	1/0	1	
S24	1	1	1/0	1	
S25	7	2	2/0	2	
S26	1	1	1/0	1	
S27	6	2	2/0	2	
S28	5	2	2/0	2	
S29	8	2	2/0	2	
S30	2	2	2/0	2	
S31	4	2	2/0	2	
S32	2	2	2/0	2	
S33	1	1	1/0	1	
S34	1	1	1/0	1	
S35	1	1	1/0	1	
S36	1	1	1/0	1	

IVC PS busbar support system

Type	No.	Design variations	Drawing (A1/A2)	Analysis point r5	Note
S37	3	2	2/0	2	
S38	1	1	1/0	1	
S39	1	1	1/0	1	
S40	1	1	1/0	1	
S41	1	1	1/0	1	
S42	1	1	1/0	1	
S43	1	1	1/0	1	
S44	1	1	1/0	1	
S45	1	1	1/0	1	
S46	1	1	1/0	1	
S47	1	1	1/0	1	
S48	1	1	1/0	1	
S49	1	1	1/0	1	
S50	1	1	1/0	1	
S51	1	1	1/0	1	
S52	1	1	1/0	1	
S53	1	1	1/0	1	
S54	1	1	1/0	1	

Type	No.	Design variations	Drawing (A1/A2)	Analysis point r5	Note
S55	2	2	2/0	2	
S56	2	2	2/0	2	
S57	2	2	2/0	2	
S58	1	1	1/0	1	
S59	1	1	1/0	1	
S60	1	1	1/0	1	
S61	1	1	1/0	1	

IVC PS busbar support system

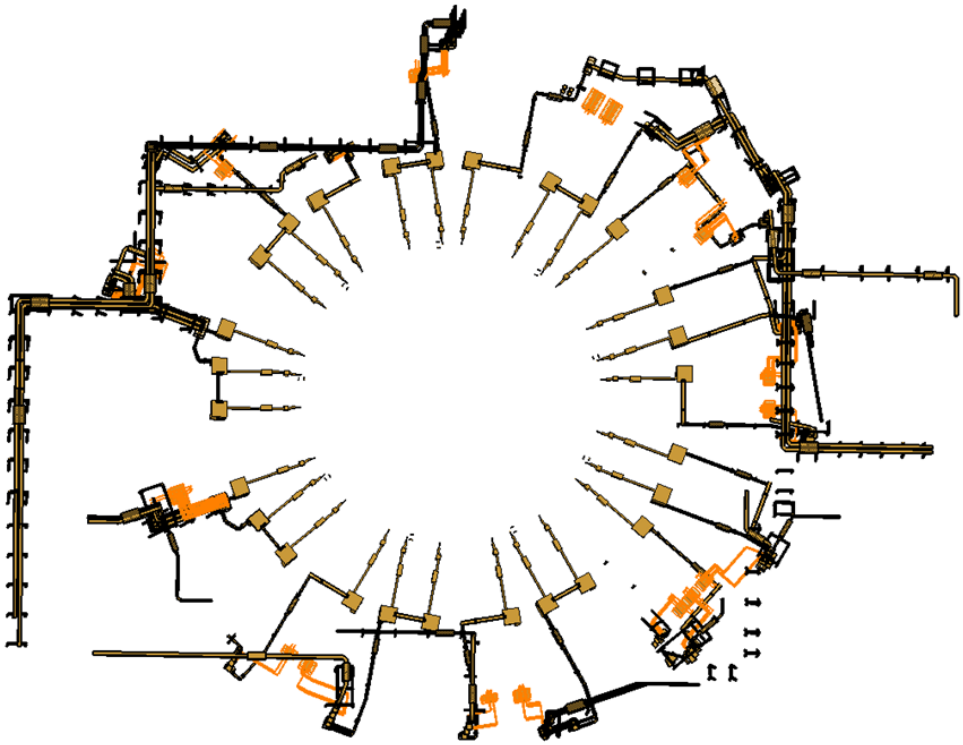
❑ SUMMARY

– Number of drawing and analysis/check point

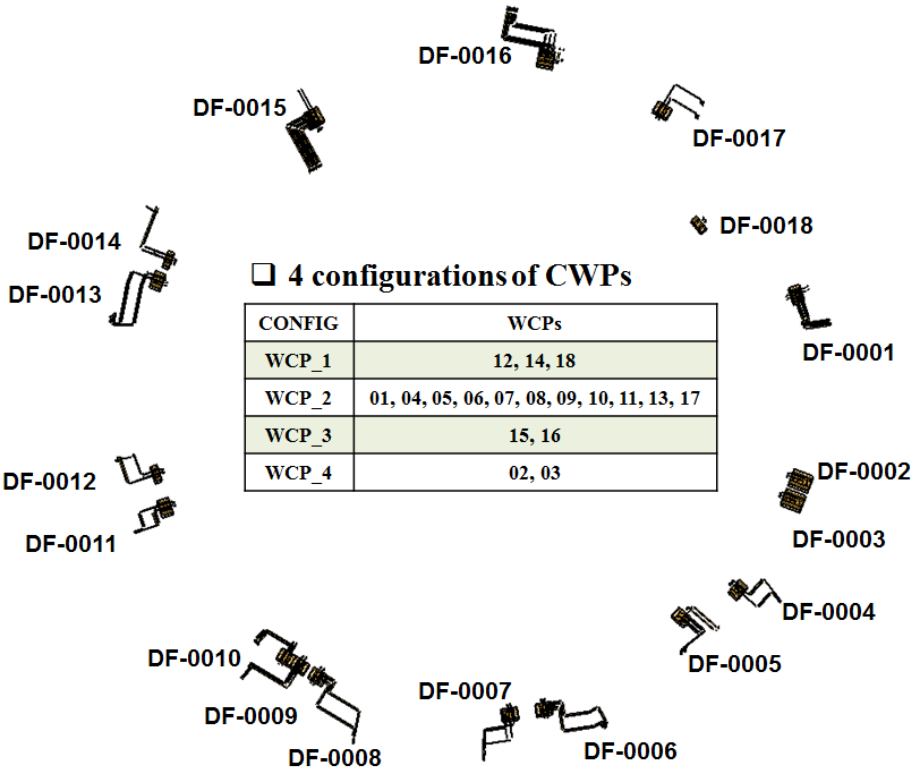
Item	No.	Drawing (A1/A2)	Analysis/check point r5
Support	417	152/28	102

Appendix D: IVC water collector panels

Water collector panels: L3



Water collector panels: L3

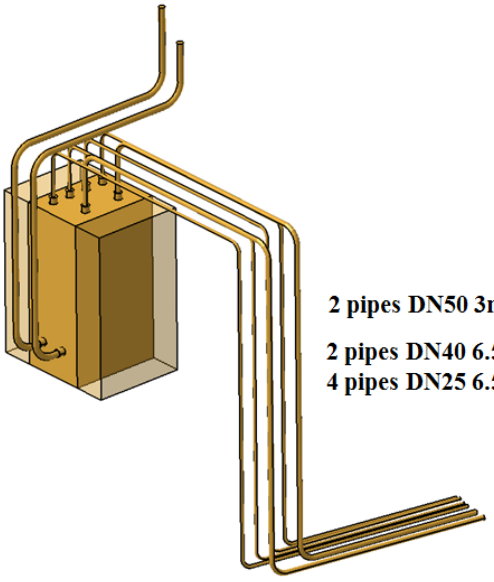


❑ 4 configurations of CWPs

CONFIG	WCPs
WCP_1	12, 14, 18
WCP_2	01, 04, 05, 06, 07, 08, 09, 10, 11, 13, 17
WCP_3	15, 16
WCP_4	02, 03

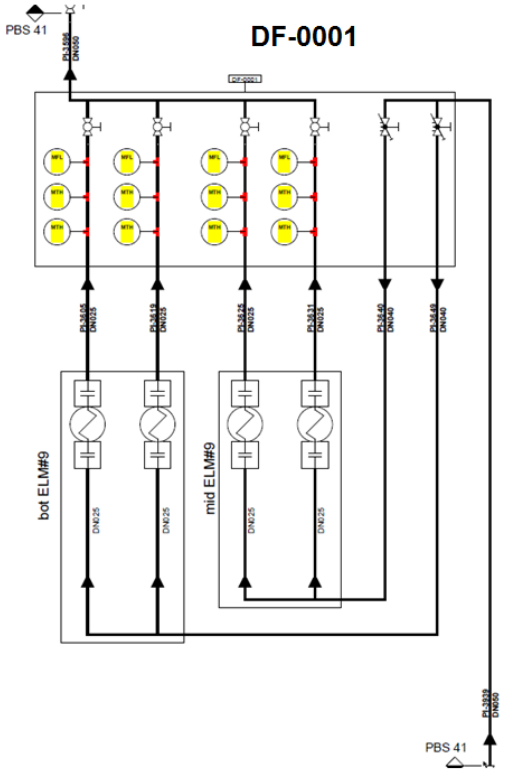
Water collector panels breakdown

DF-0001



2 pipes DN50 3m

2 pipes DN40 6.5m
4 pipes DN25 6.5m



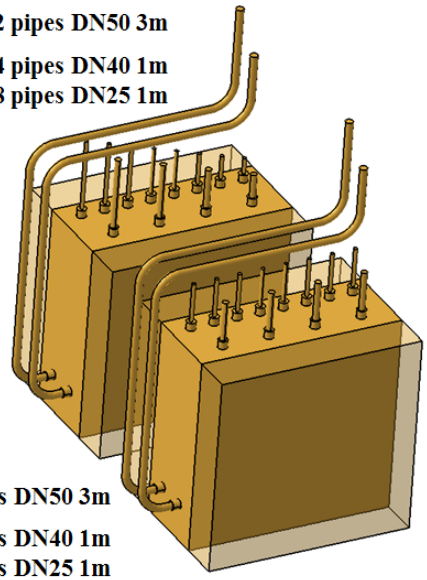
Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

Water collector panels breakdown

DF-0002 DF-0003

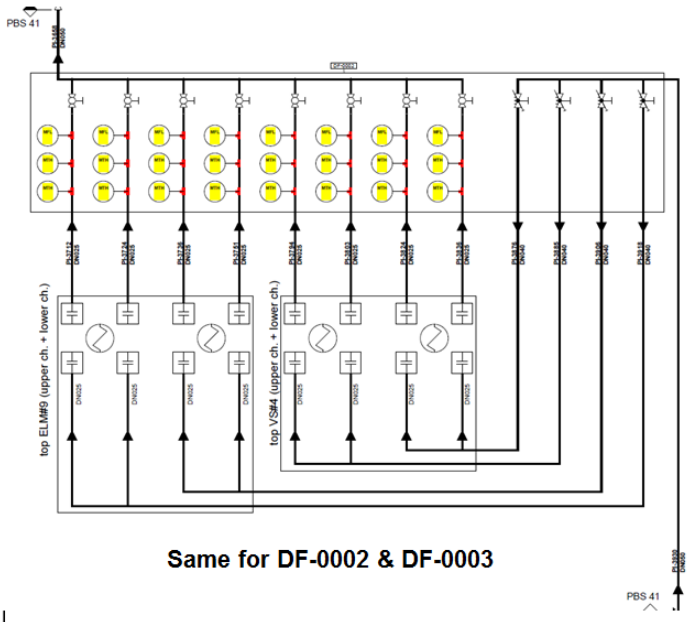
2 pipes DN50 3m

4 pipes DN40 1m
8 pipes DN25 1m



2 pipes DN50 3m

4 pipes DN40 1m
8 pipes DN25 1m

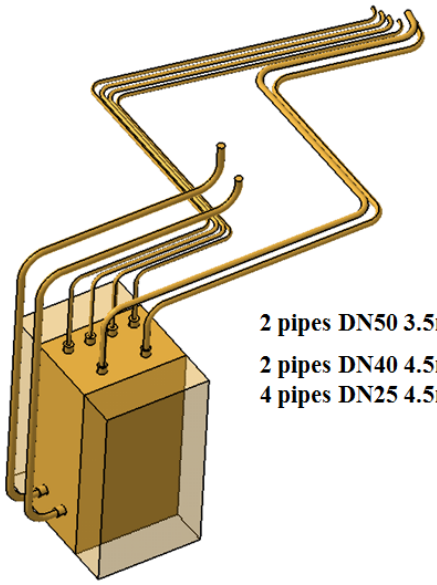


Same for DF-0002 & DF-0003

Item	No.	Drawing	Analysis point
Cooling pipe	14/14	3/3	2/2

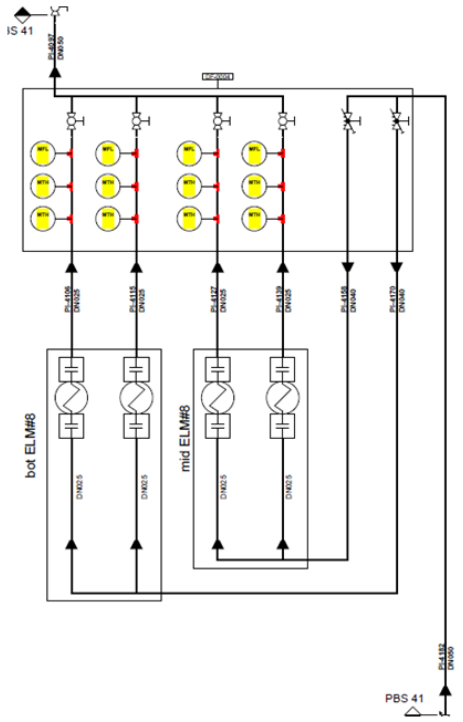
Water collector panels breakdown

DF-0004



2 pipes DN50 3.5m

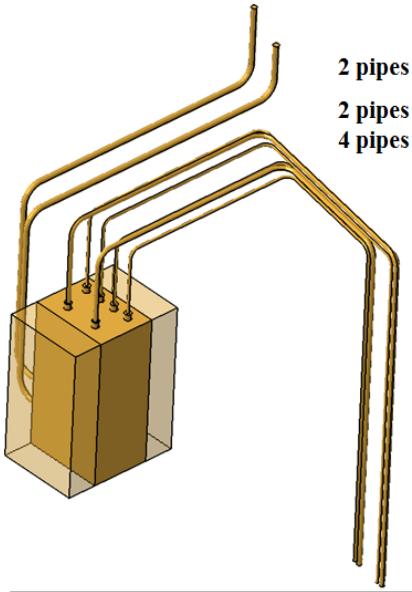
2 pipes DN40 4.5m
4 pipes DN25 4.5m



Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

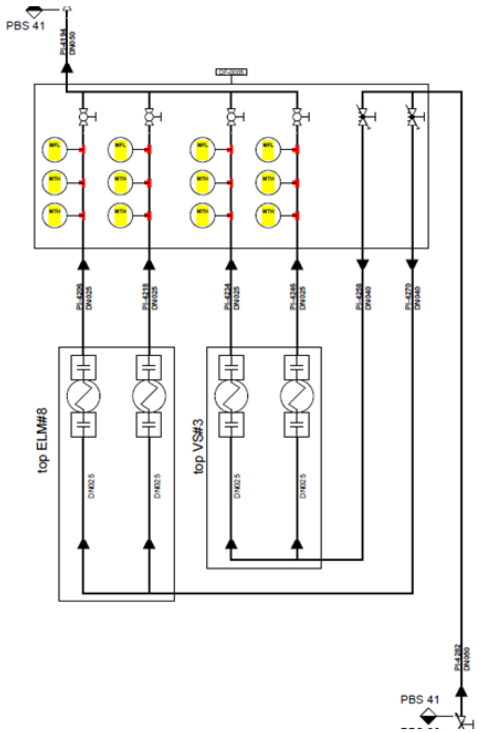
Water collector panels breakdown

DF-0005



2 pipes DN50 4.5m

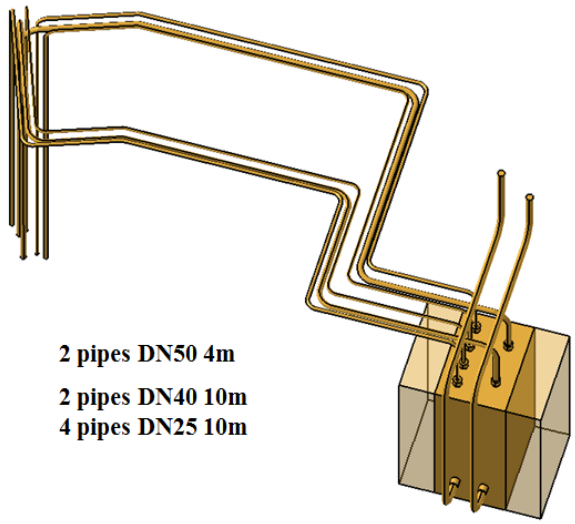
2 pipes DN40 8m
4 pipes DN25 8m



Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

Water collector panels breakdown

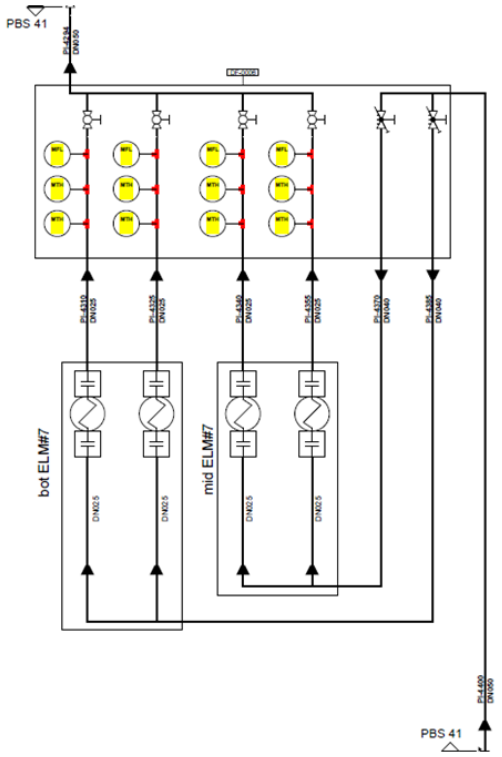
DF-0006



2 pipes DN50 4m

2 pipes DN40 10m

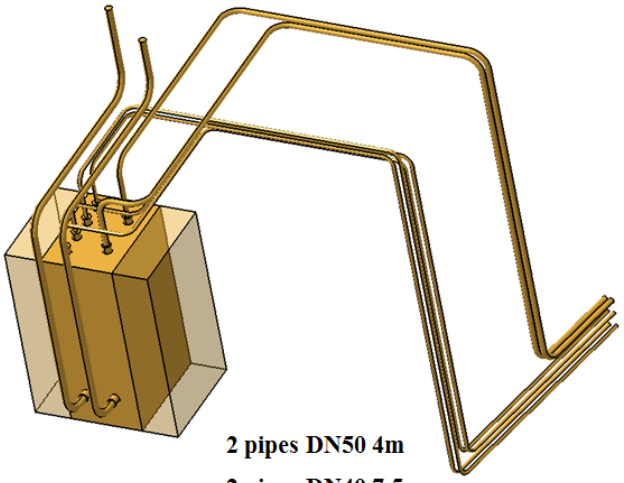
4 pipes DN25 10m



Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

Water collector panels breakdown

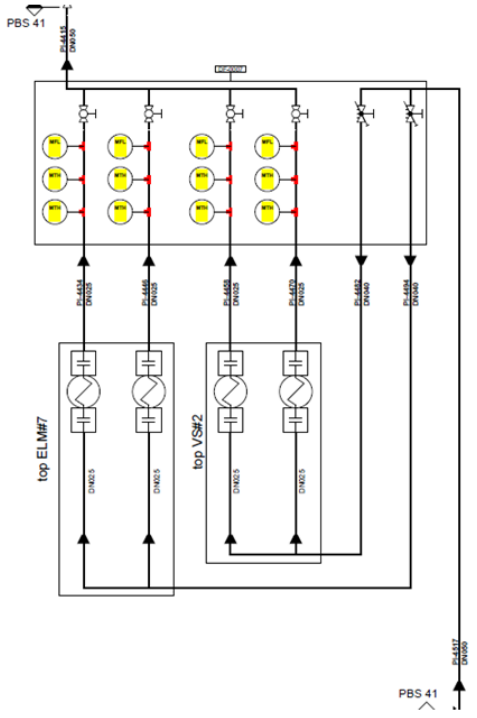
DF-0007



2 pipes DN50 4m

2 pipes DN40 7.5m

4 pipes DN25 7.5m

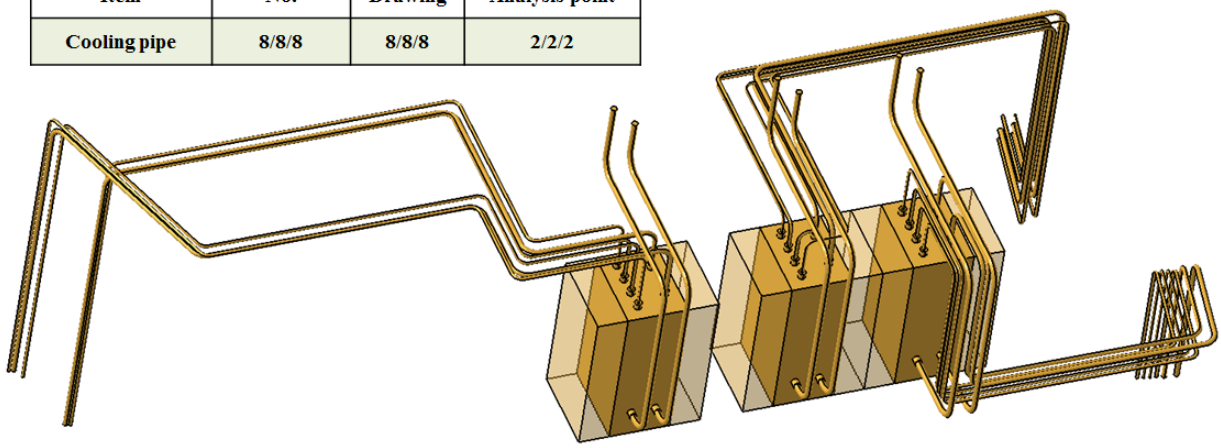


Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

Water collector panels breakdown

DF-0008 DF-0009 DF-0010

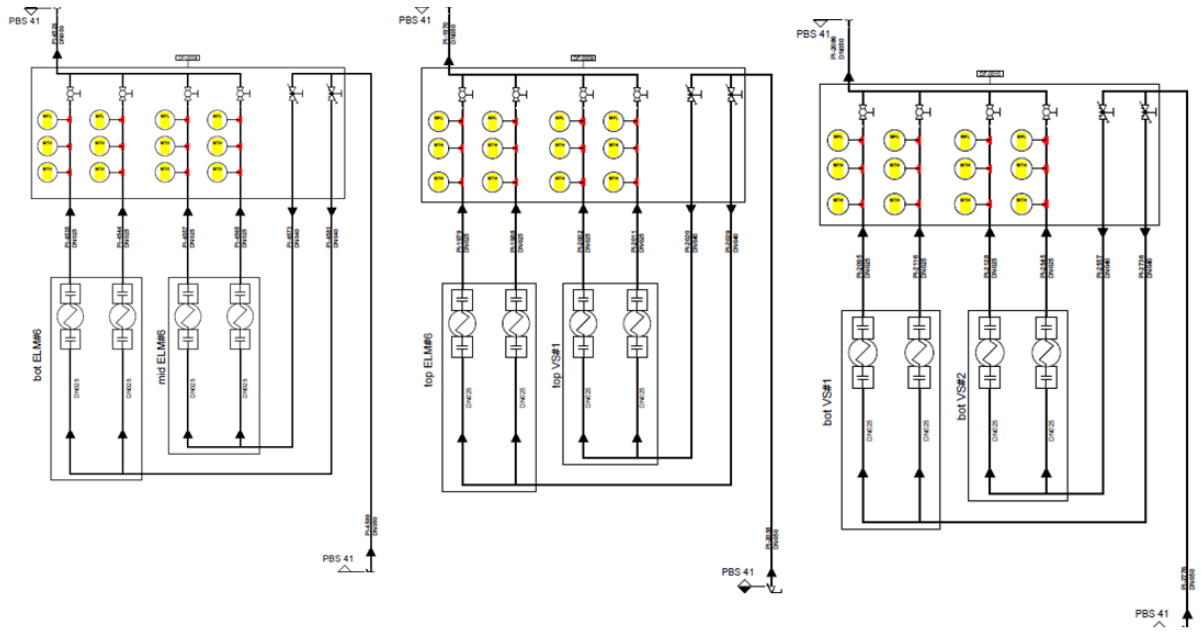
Item	No.	Drawing	Analysis point
Cooling pipe	8/8/8	8/8/8	2/2/2



DF-0008	DF-0009	DF-0010
2 pipes DN50 4m	2 pipes DN50 4m	2 pipes DN50 4.5m
2 pipes DN40 9.5m	2 pipes DN40 8m	2 pipes DN40 8m
4 pipes DN25 9.5m	4 pipes DN25 8m	4 pipes DN25 8m

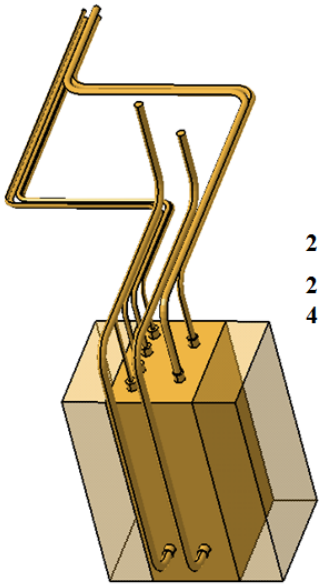
Water collector panels breakdown

DF-0008 DF-0009 DF-0010



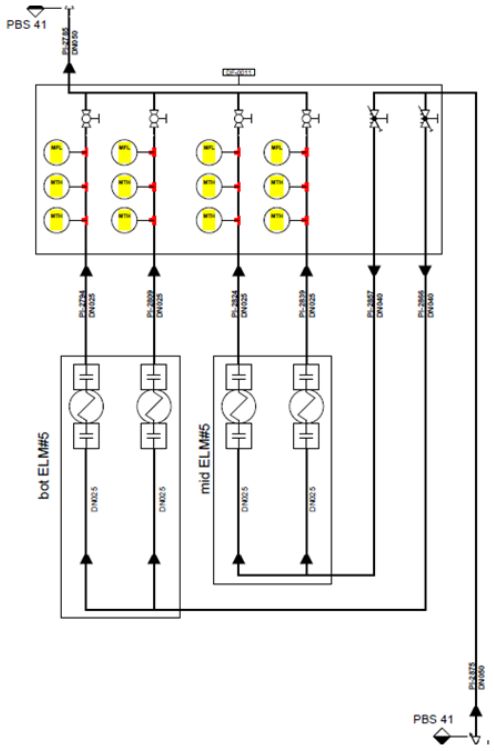
Water collector panels breakdown

DF-0011



2 pipes DN50 4m

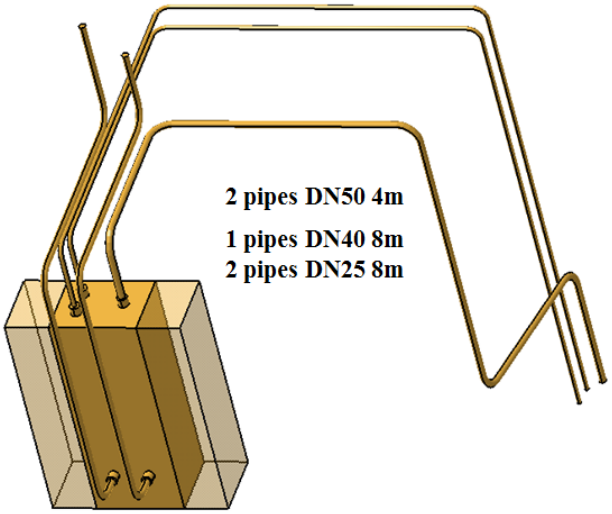
2 pipes DN40 4.5m
4 pipes DN25 4.5m



Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

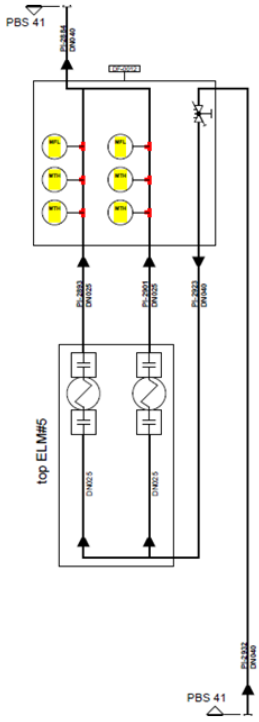
Water collector panels breakdown

DF-0012



2 pipes DN50 4m

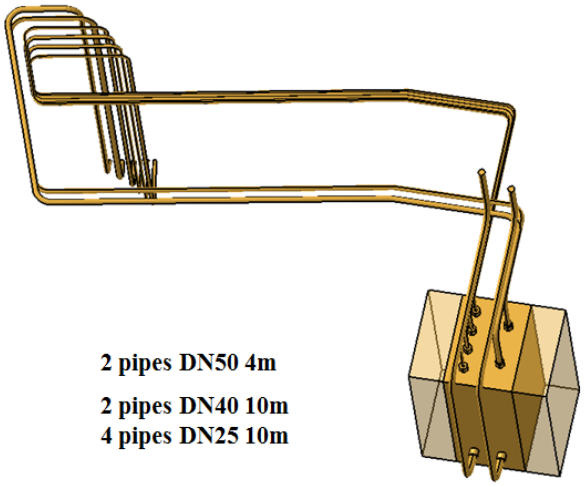
1 pipes DN40 8m
2 pipes DN25 8m



Item	No.	Drawing	Analysis point
Cooling pipe	5	5	2

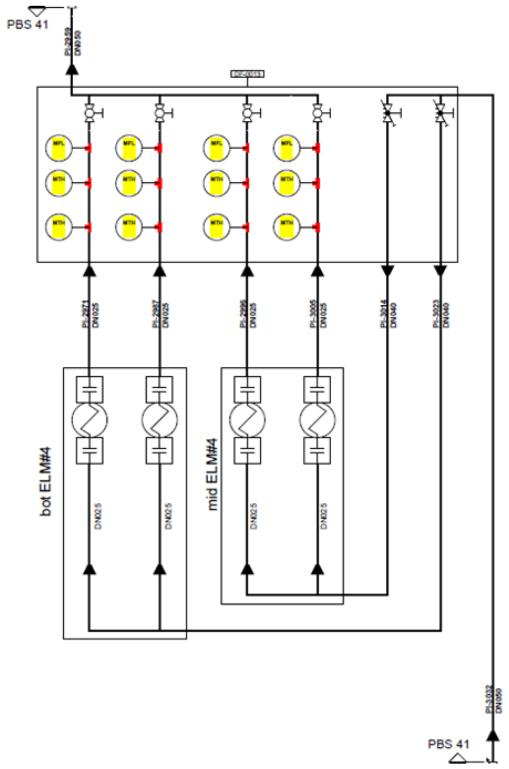
Water collector panels breakdown

DF-0013



2 pipes DN50 4m

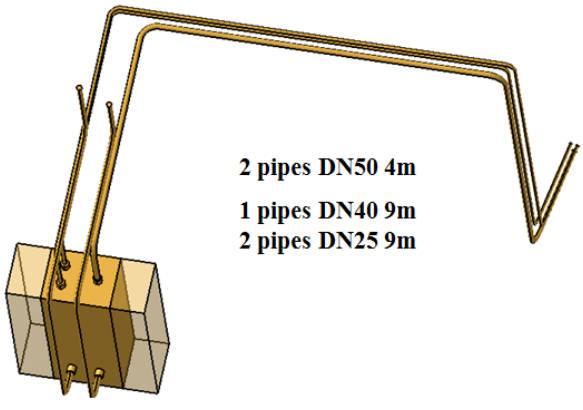
2 pipes DN40 10m
4 pipes DN25 10m



Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

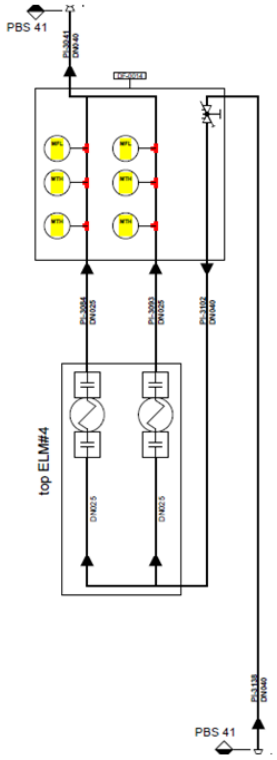
Water collector panels breakdown

DF-0014



2 pipes DN50 4m

1 pipes DN40 9m
2 pipes DN25 9m



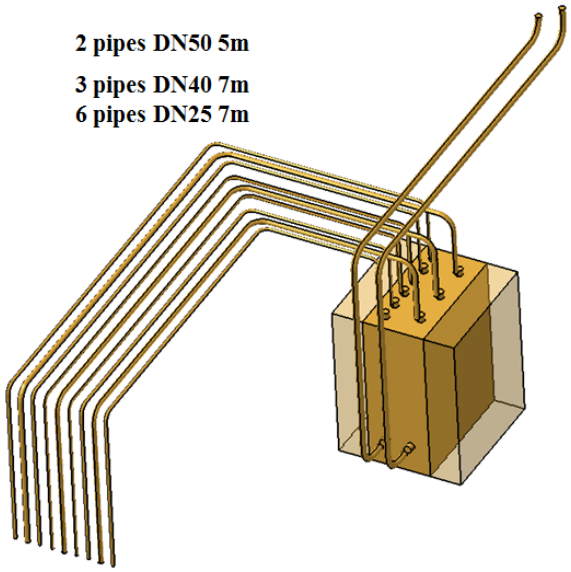
Item	No.	Drawing	Analysis point
Cooling pipe	5	5	2

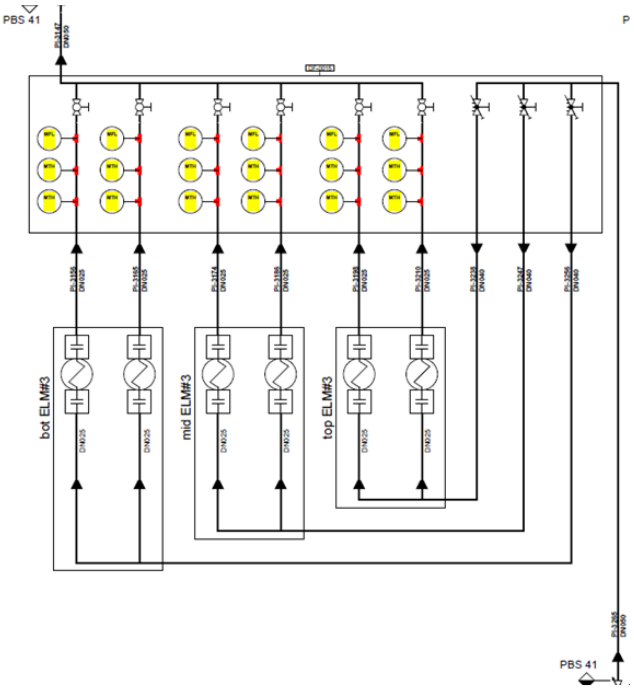
Water collector panels breakdown

DF-0015

2 pipes DN50 5m

3 pipes DN40 7m
6 pipes DN25 7m





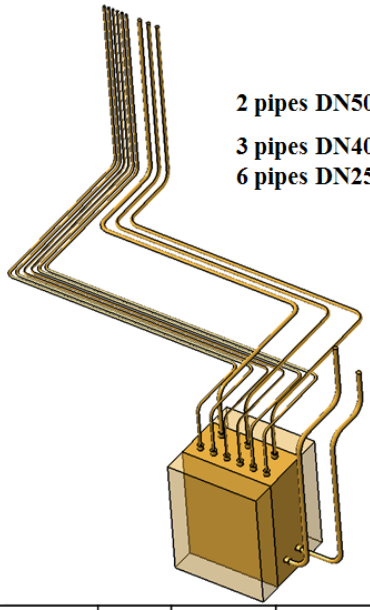
Item	No.	Drawing	Analysis point
Cooling pipe	11	11	2

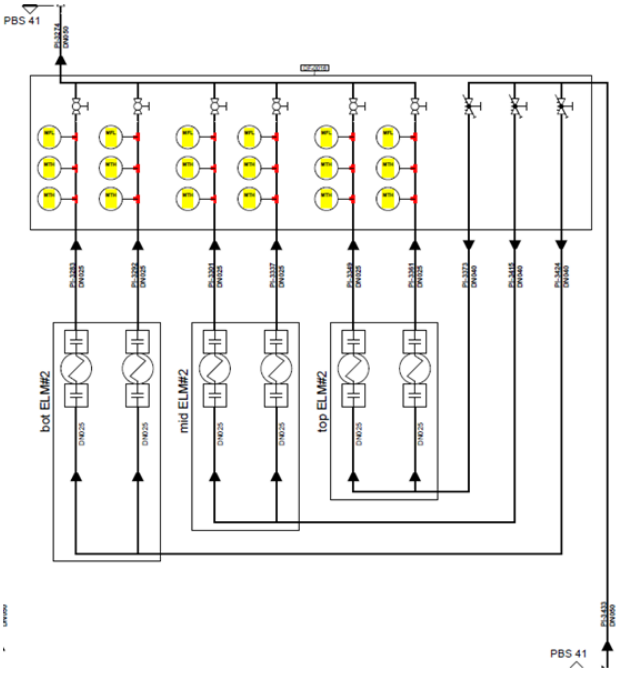
Water collector panels breakdown

DF-0016

2 pipes DN50 3m

3 pipes DN40 7m
6 pipes DN25 7m

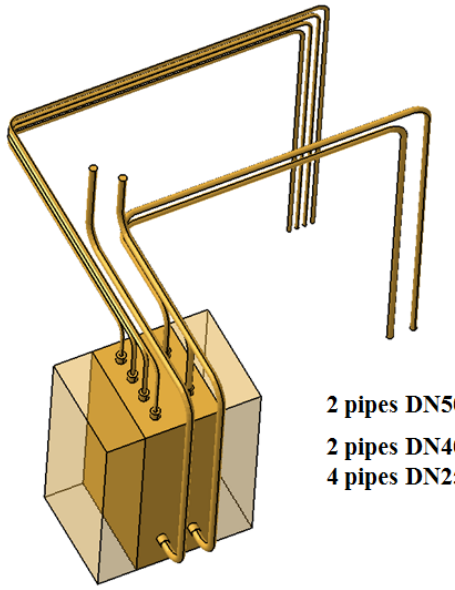




Item	No.	Drawing	Analysis point
Cooling pipe	11	11	2

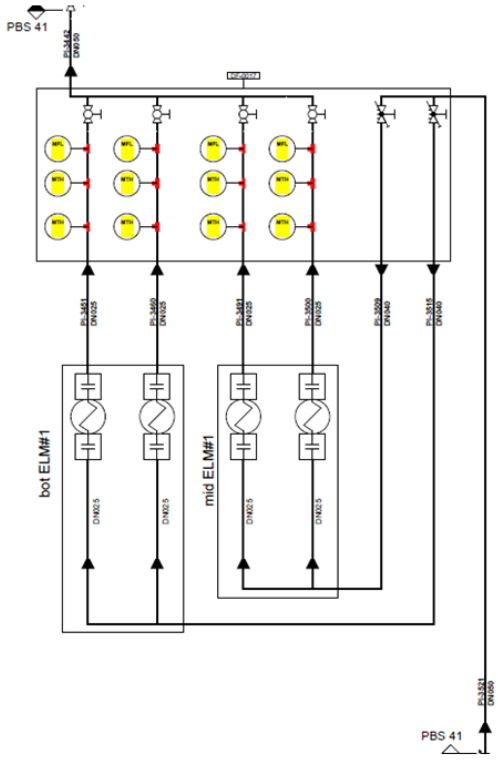
Water collector panels breakdown

DF-0017



2 pipes DN50 3.5m

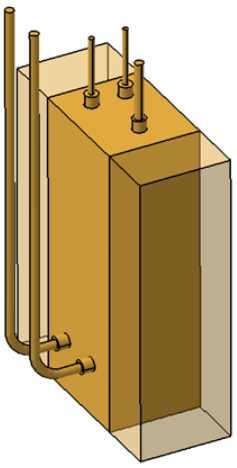
2 pipes DN40 7m
4 pipes DN25 7m



Item	No.	Drawing	Analysis point
Cooling pipe	8	8	2

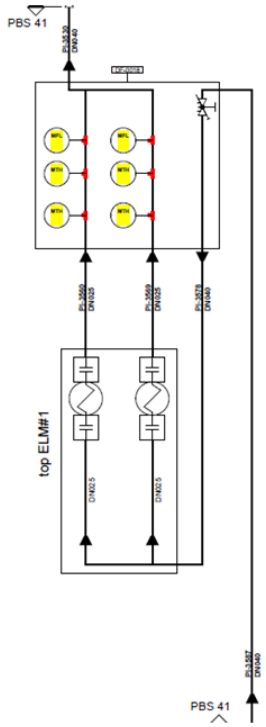
Water collector panels breakdown

DF-0018



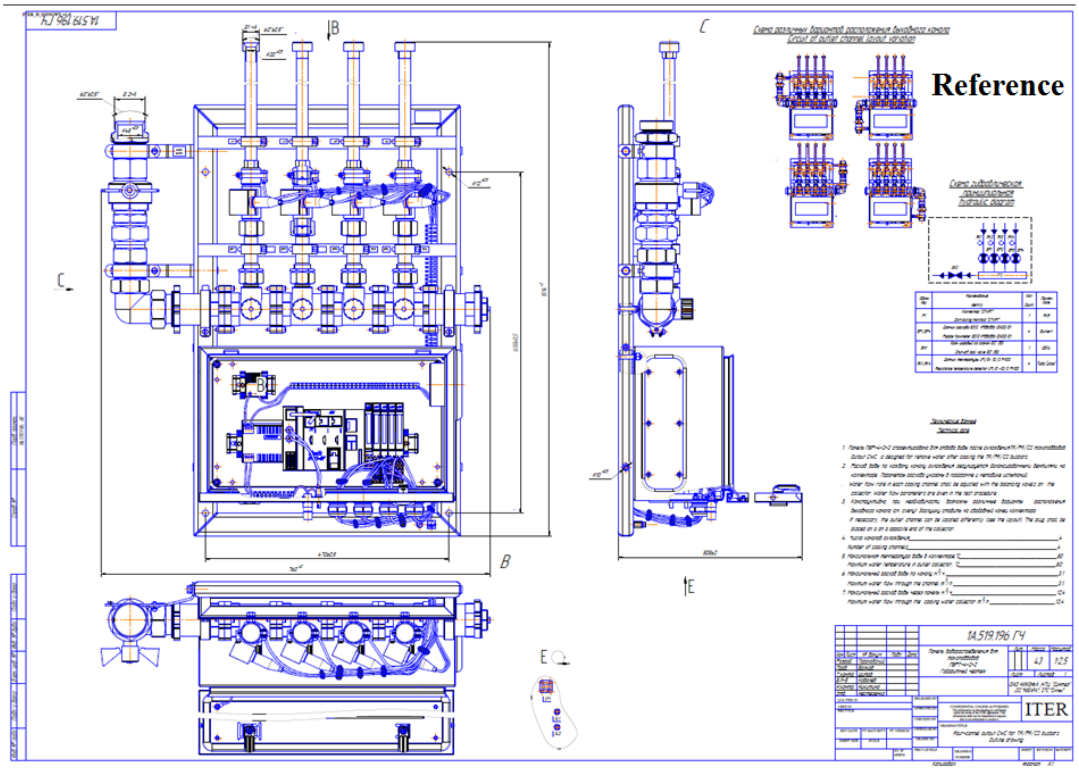
2 pipes DN50 2m

1 pipes DN40 1m
2 pipes DN25 1m



Item	No.	Drawing	Analysis point
Cooling pipe	5	3	2

Reference: Four-cannel output CWC for TF/PF/CS busbars



Water collector panels: L3

❑ SUMMARY

— WCPs

CONFIG	WCPs	Type	Drawing A1
WCP_1	12, 14, 18	Input & output	20/20
WCP_2	01, 04, 05, 06, 07, 08, 09, 10, 11, 13, 17	Input & output	20/20
WCP_3	15, 16	Input & output	20/20
WCP_4	02, 03	Input & output	20/20
Total			160

— Cooling pipes

Item	No.	Drawing A3	Analysis point r4
Cooling pipe	153	119	36

Water collector panels: L4

❑ SUMMARY

– WCPs

CONFIG	WCPs	Type	Drawing A1
WCP_1	12, 14, 18	Input & output	No additional drawings are expected considering same design with L3
WCP_2	01, 04, 05, 06, 07, 08, 09, 10, 11, 13, 17	Input & output	
WCP_3	15, 16	Input & output	
WCP_4	02, 03	Input & output	
Total			

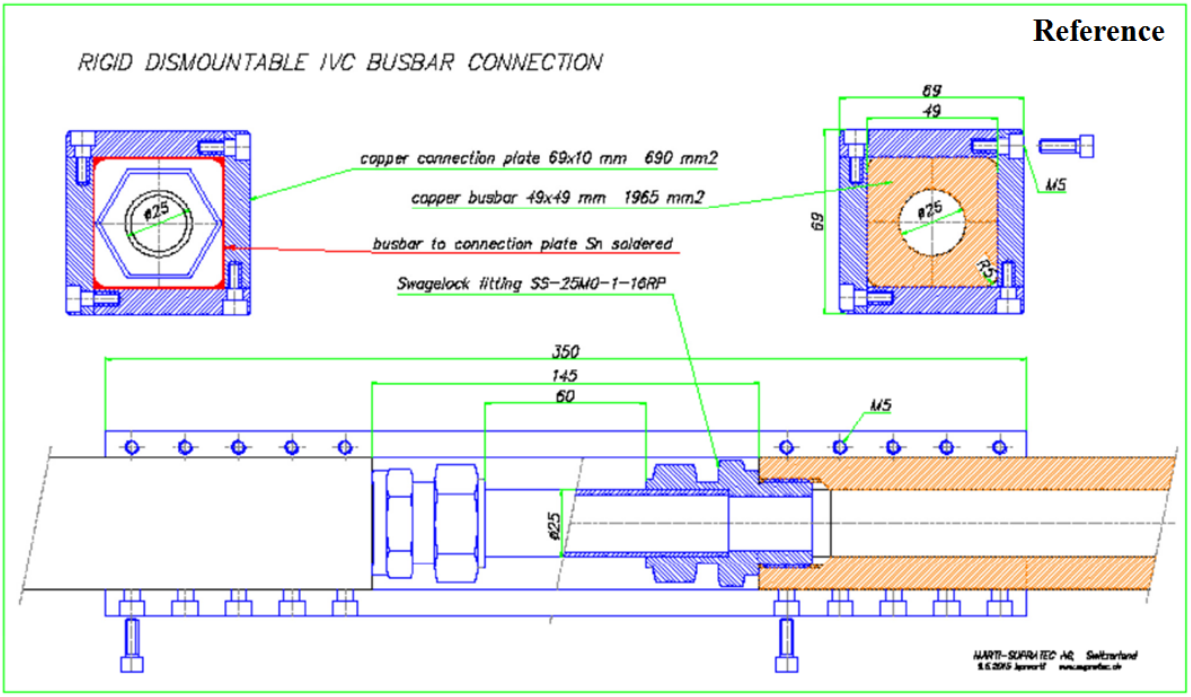
– Cooling pipes

Item	No.	Drawing A3	Analysis point r4
Cooling pipe	153	119	36

Note: the water collector panels in L4 are not reflected in the 3D model, the same number of WCPs and cooling pipes are assumed tentatively.

Appendix E: IVC rigid connection

Rigid connection proposal



Rigid connection

❑ SUMMARY

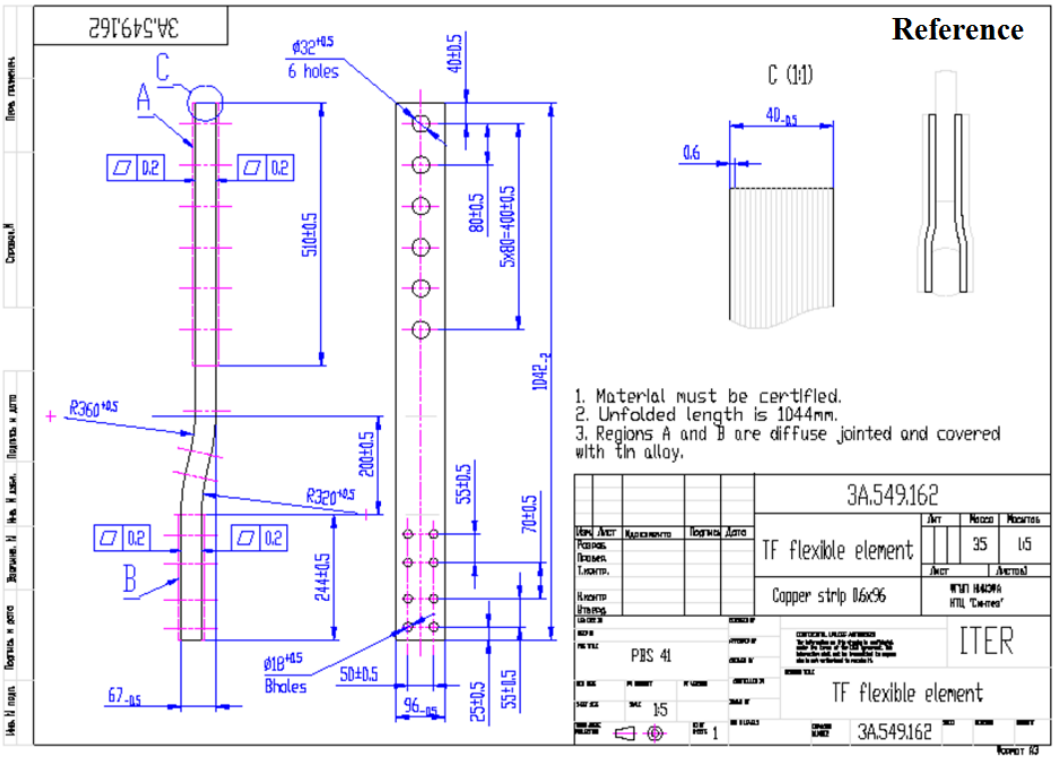
– Number of rigid connection and flexible link

Item	Config	No.	Design variations*	Drawing A1	Analysis points r3/r4
Rigid connection	1 busbar	60	4	8	4/4
	2 busbar	32	4	8	4/4
	3 busabr	15	6	12	6/6
	4 busbar	3	4	8	4/4
	5 busbar	1	1	2	1/1
	8 busbar	1	1	2	1/1
Total				40	20/20

*Estimation depending on the bends and offset at the connection.

Appendix F: IVC flexible link

Reference: TF flexible link drawing



Flexible link

❑ SUMMARY

– Number of flexible link

Item	Config	No.	Design variations	Drawing A1	Analysis points r3/r4
Flexible link	1 layer	62	2	2	2/2
	2 layers	8	1	1	1/1
Total				3	3/3